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Revision 1
Project No. 23130
July 2003

Field Sampling Plan for Monitoring Type B Probes for the Operable Unit 7-13/14 Integrated Probing Project

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Washington Group International

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Approved by

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ABSTRACT

Various types of probes are being installed in the Subsurface Disposal Area of the Radioactive Waste Management Complex at the Idaho National Engineering and Environmental Laboratory. The probes are part of the Operable Unit (OU) 7-13/14 integrated probing project that will collect subsurface contamination data. The data will verify and validate the OU 7-13/14 comprehensive remedial investigation/feasibility study and support selection of remedial alternatives in the record of decision. Type A probes will be installed first, and will be monitored with nuclear logging devices. Data from the Type A probes will be used to site the following Type B probes: tensiometers, suction lysimeters, vapor ports, and visual, moisture, and geochemical probes.

This field sampling plan describes how and where Type B probes will be installed, how samples will be collected from the Type B probes, and how the Type B probes will be monitored.

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ACRONYMS

ALS	alpha spectrometry
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CSA	CERCLA storage area
CY	calendar year
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DU	depleted uranium
EDF	engineering design file
FSP	field sampling plan
GC/MS	gas chromatography/mass spectrometry
GFP	gas flow proportional
GMS	gamma spectrometry
HDPE	high-density polyethylene
HEPA	high-efficiency particulate air
ICPP	Idaho Chemical Processing Plant
ICP/MS	inductively coupled/mass spectrometry
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IWTS	Integrated Waste Tracking System
LEPS	low-energy photon scintillation
LLW	low-level waste
LSC	liquid scintillation
OCVZ	organic contamination in the vadose zone
OU	operable unit
PCB	polychlorinated biphenyl
PPE	personal protective equipment

QA	quality assurance
QAPjP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RDL	required detection limit
RFP	Rocky Flats Plant
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
SVR	soil vault row
SMO	Sample Management Office
SOW	statement of work
TPR	technical procedure
TRA	Test Reactor Area
TRU	transuranic
TSA	Transuranic Storage Area
VOA	volatile-organic analysis
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	waste area group
WGS	Waste Generator Services

Field Sampling Plan for Monitoring Type B Probes for the Operable Unit 7-13/14 Integrated Probing Project

1. INTRODUCTION

1.1 Purpose

This field sampling plan (FSP) describes how newly installed Type B probes in the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering and Environmental Laboratory (INEEL) will be monitored, and how samples will be collected. Information gained from this effort will be used to support assessment of the following: (1) infiltration through the waste, (2) release rate and solubility of uranium, (3) release rate of C-14, and (4) mass of the volatile organic compound (VOC) source remaining. The results will support the Operable Unit (OU) 7-13/14 integrated probing project and ultimately verify and validate the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) -based (42 USC § 9601 et seq.) OU 7-13/14 comprehensive remedial investigation/feasibility study (RI/FS). Operable Unit 7-13/14 is the comprehensive OU for Waste Area Group (WAG) 7, which comprises the RWMC.

1.2 Scope

The work described in this FSP will verify and validate the comprehensive OU 7-13/14 RI/FS under the *Federal Facility Agreement and Consent Order and Action Plan* (DOE-ID 1991). This FSP describes how Type B probes will be monitored and how samples will be collected from instrumented Type B probes installed as part of the OU 7-13/14 integrated probing project at the RWMC. Various types of probes are being installed in the SDA to support this project. The first phase of probing used Type A probes that were successfully installed in Pit 9 for the OU 7-10 staged interim action project. These Type A probes were monitored using nuclear logging devices, and the resulting data were used to site the Type B probes installed as the second phase of the integrated probing project. This FSP focuses on Type B probe location and monitoring. Data obtained from Type B probes will help fill previously identified data gaps (INEEL 2000; Day et al. 2001).

Type B probes include tensiometers, suction lysimeters, vapor ports, and visual, soil moisture, and geochemical probes. The *Operable Unit 7-13/14 Plan for the Installation, Logging, and Monitoring of Probeholes in the Subsurface Disposal Area* (INEEL 2000), which is known as the Probehole Plan, outlines the general approach to the integrated probing project, while this FSP defines the specific sampling and monitoring requirements necessary to collect data from the Type B probes. The final locations of the Type B probes will depend on analyses of data being gathered from existing and future Type A probes.

This FSP and the *Quality Assurance Project Plan for WAGs 1, 2, 3, 4, 5, 6, 7, 10, and Inactive Sites* (QAPjP) (DOE-ID 2002a) together are considered the sampling and analysis plan for the Type B probe phase of the integrated probing project. This FSP has been prepared in accordance with INEEL Management Control Procedure (MCP) MCP-227, "Sampling and Analysis Process for CERCLA and D&D Activities." This FSP describes the field activities that are part of the investigation, and the QAPjP describes the processes and programs that ensure that the generated data will be suitable for the intended use.

1.3 Site Background

1.3.1 Site Location, History, and Use

The INEEL, located 42 mi (68 km) west of Idaho Falls, Idaho, occupies 890 mi^2 (2,305 km^2) of the northwestern portion of the eastern Snake River Plain. The INEEL is bounded on the northwest by the Lost River, Lemhi, and Beaverhead mountain ranges. The remainder of the INEEL is bounded by the eastern Snake River Plain. Elevations on the INEEL range from 5,200 ft (1,585 m) in the northeast to 4,750 ft (1,448 m) in the southwest, with the average being 5,000 ft (1,524 m). The INEEL was established in 1949 by the U.S. Atomic Energy Commission to build, operate, and test various nuclear reactors and fuel processing plants and to provide support facilities. Today, the INEEL supports government-sponsored projects including energy, defense, environmental, and ecological research.

The RWMC is on the southwestern portion of the INEEL (see Figure 1). The facility encompasses three major operational areas: the SDA, the Transuranic Storage Area (TSA), and a combined operations and administration area. The SDA occupies 97 acres (39 hectares) of buried waste within the SDA and the TSA occupies 57.5 acres (23 hectares) of stored aboveground transuranic (TRU) waste. Since 1962, TRU waste and low-level radioactive waste have been buried in pits, trenches, soil vaults, and on one aboveground pad (Pad A) in the SDA. The waste also contains nonradioactive hazardous material, such as mercury, beryllium, asbestos, zirconium fines, solidified acids and bases, solvents and degreasing agents, and sodium and potassium salts. In 1970, the disposal of TRU waste in the SDA was discontinued when the TSA was established as an interim storage facility. Disposal of hazardous material ceased in 1983. Since then, only low-level radioactive waste has been disposed of in the SDA. In addition to interim storage, operations at the TSA include waste segregation, examination, and certification. The operations and administration area contains administrative offices, security and gatehouse operations, radiological control support, maintenance buildings, equipment storage, and miscellaneous support facilities. A more detailed summary of RWMC operations is in the OU 7-13/14 Interim Risk Assessment (Becker et al. 1998).

In addition to waste generated at the INEEL, waste from other U.S. Department of Energy (DOE) facilities, primarily the Rocky Flats Plant (RFP) in Golden, Colorado, was stored and disposed of at the RWMC. The SDA includes numerous pits, trenches, and soil vaults where radioactive and organic waste was placed, as well as a large pad where waste was placed above grade and covered (see Figure 2). The TSA has been used since the early 1970s for retrievable storage of TRU waste on earthen-covered pads and in facilities. The boundary of WAG 7 is defined as the RWMC fence, with the SDA as a fenced portion within the RWMC. The boundary includes all surface and subsurface areas. The current RWMC mission is to provide waste management for present and future needs of the INEEL and assigned DOE off-Site generators of low-level waste (LLW) and TRU waste, and to retrieve, examine, and certify stored TRU waste for ultimate shipment to the DOE Waste Isolation Pilot Plant in Carlsbad, New Mexico.

The majority of probeholes will be installed in Pits 4 and 10 in the three focus areas identified in the original 1999 Probehole Plan (Becker et al. 1999). Pit 4 was open from January 1963, to September 1967, and Pit 10 was open from June 1968, to July 1971. Each pit has an approximate surface area of 111,730 ft^2 (10,380 m^2), and an average depth of 14.5 ft (4.4 m) (Becker et al. 1998). Some activities will also be conducted in Pits 5 and 6. Pit 5 was open from June 1963, to December 1966, and has an estimated surface area of 108,754 ft^2 (10,104 m^2), while Pit 6 was open from May 1967, to October 1968, and has an estimated surface area of 54,984 ft^2 (5,108 m^2). Waste buried in these pits was generated primarily by weapons production operations at the RFP and from various operations at the INEEL. The sludge and other waste material from RFP buried in the SDA contain a variety of radionuclides and organic and inorganic compounds. Other materials in the pits include LLW from the INEEL and small quantities of LLW from miscellaneous off-Site facilities. The primary focus of probes installed in these

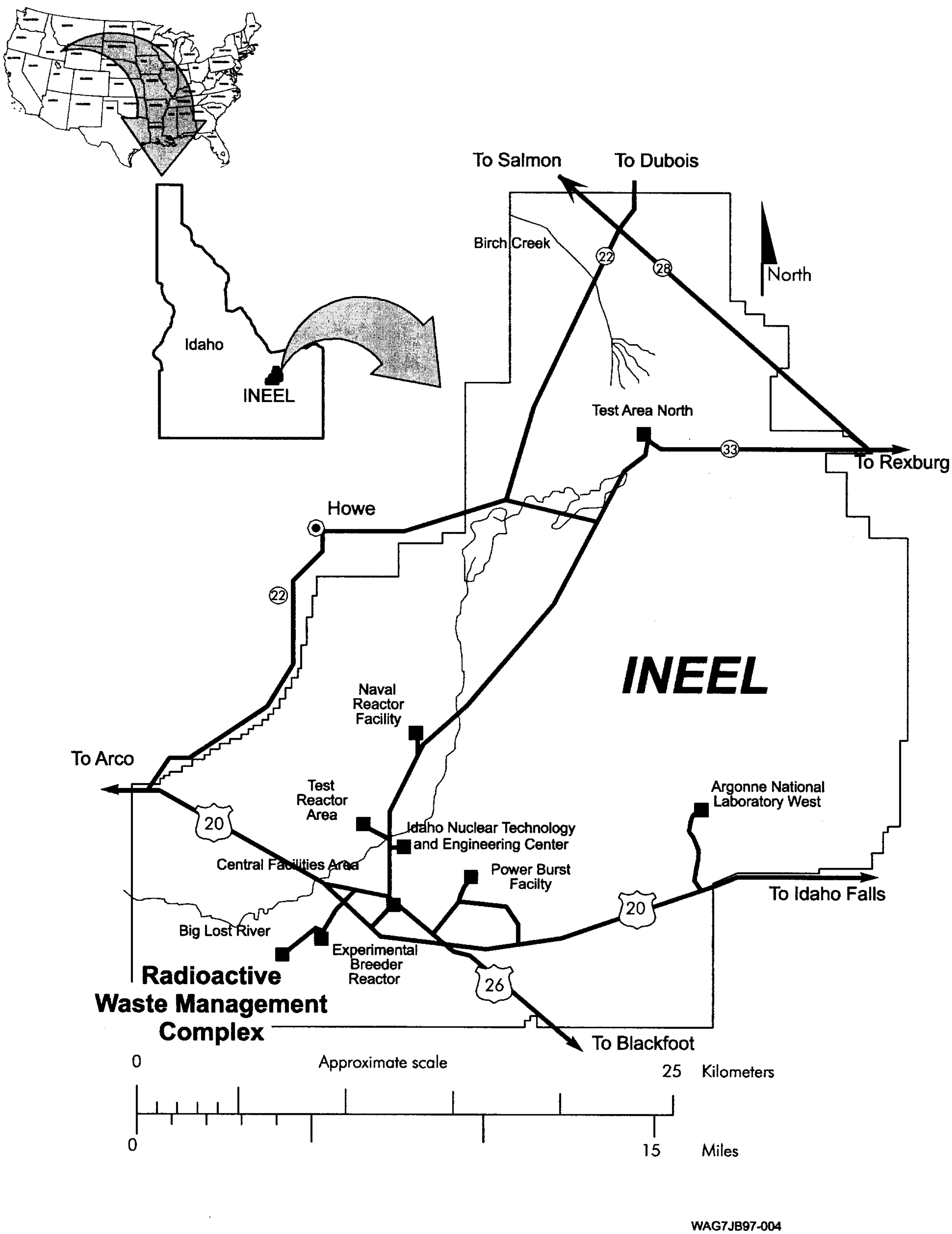

Figure 1. Location of the Radioactive Waste Management Complex at the INEEL.

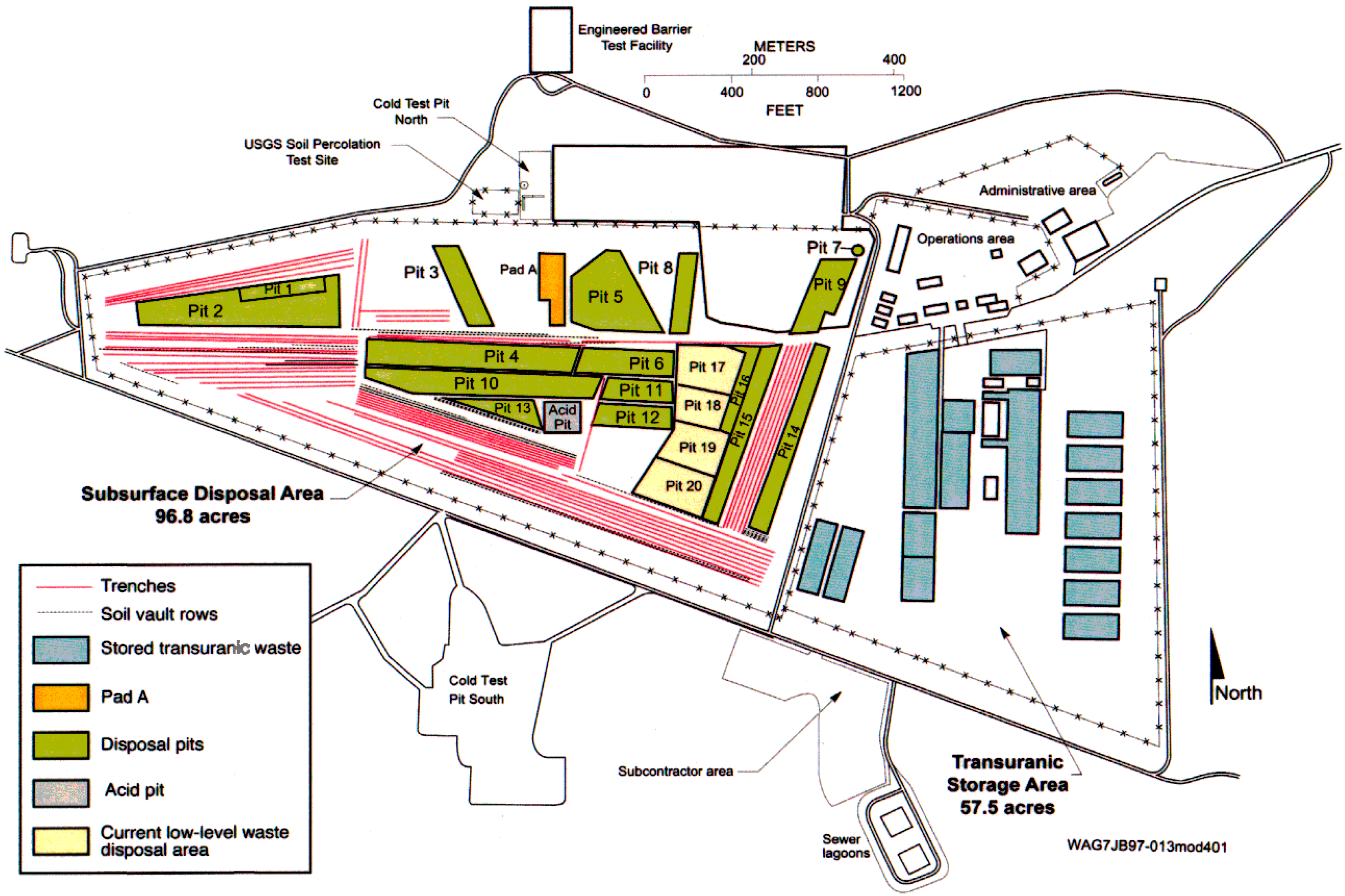

Figure 2. Physical layout of the Radioactive Waste Management Complex.

pits is to evaluate chlorinated VOCs, uranium, and high-activity americium and neptunium in the waste buried in the pits.

High-activity waste associated with soil vault row (SVR) disposal is also being investigated as part of this FSP. Because of possible exposure, this waste was buried in subsurface soil vaults augered into the RWMC subsurface. The materials being evaluated are activated beryllium and stainless steel. Soil vault disposal began in 1977 to minimize personnel exposure to ionizing radiation. The soil vaults were designed for disposal of high-radiation waste, defined as materials producing a beta-gamma exposure rate of greater than 500 mR/hour at a distance of 3 ft (0.9 m). The soil vaults are unlined vertical cylindrical borings ranging from 1.25 to 6.5 ft (0.4 to 2 m) in diameter and averaging about 12 ft (3.6 m) deep. If basalt had been penetrated during drilling of the soil vault, at least 2 ft (0.6 m) of soil was placed in the hole to cover the bedrock underlying the vault. Soil vaults are drilled in rows with individual vaults separated from their neighboring vaults in the same or adjacent rows by a minimum of 2 ft (0.6 m). The SVRs are located throughout the southern two-thirds of the SDA. Following placement, waste disposed of in-soil vaults was covered with several ft of soil.

1.3.2 Subsurface Disposal Area Geology

The SDA is located on the Snake River Plain of southeastern Idaho. The gently rolling terrain of this region is a result of geologically recent, basalt lava flows and associated volcanic features, such as cinder cones, vents, and pressure ridges. Soil is generally shallow to nonexistent, with the greatest thickness in the basalt depressions. Within the SDA, the maximum thickness of soil is about 30 ft (9 m). The bedrock in this region is a series of generally horizontal basalt flows separated by thin, discontinuous sedimentary interbeds. These basalt flows have morphology that varies from dense, massive material to vesicular or highly fractured rock containing lava tubes. The interbeds are composed of unconsolidated sediment, cinders, and volcanic breccia.

1.3.3 Subsurface Disposal Area Hydrogeology

Water movement in the vadose zone of the SDA is complicated. The properties of the sediment and basalt with which the water comes in contact and the matric potential gradients determine the direction and velocity of flow. At saturated or nearly saturated conditions, water within the SDA soil will generally flow downward until it reaches a relatively impermeable zone, such as a basalt flow or fine sediment overlying the basalt flow. Water will then flow nearly horizontally along the interface until it reaches a zone of higher permeability, such as a fracture zone, where it will move downward. Localized saturated conditions (e.g., near ditches) generally occur in the springtime because of rapid localized snow melt. Most of the year, the near-surface soil is not near saturation, and the general flow direction of the water in the topsoil zone is vertically upward because of evapotranspiration.

2. DESCRIPTION OF TYPE B PROBE INSTRUMENTS

The following six types of instrumented Type B probes are being monitored as part of this investigation:

- Tensiometers
- Soil moisture probes
- Lysimeters
- Vapor ports
- Visual probes
- Geochemical probes (pH and oxidation-reduction potential probes).

The general locations of the Type B probes were determined based on data gaps and waste disposal information. The specific locations of the Type B probes are being refined based on the results of the Type A probing and logging, which are discussed in the following section. This section describes general construction and primary use of each instrument. A technical and functional requirements document (INEEL 2001) was prepared which identified the technical and functional requirements for the systems, structures, and components supporting the Type B investigation. Type B probe design and construction are specifically described in the engineering design files (EDFs) referenced below. All but the visual probes are being installed in accordance with TPR-1672, "Type B Probe Installation." The visual probes are being installed in accordance with TPR-1673, "Type B Visual Probe Installation." The approach to vertical placement is described below for each type of instrument sensor or inlet port. Appendix A provides an interpretation of the contacts (i.e., plane of interest or the "contact" between the waste zone and underburden soil) between the waste and overburden and underburden soils surrounding the original Type A probes. The interpretation is based on Type A nuclear logging results. Also contained in Appendix A is a suggested vertical placement of completed Type B probes surrounding an existing Type A probe. The suggested vertical placement is based on the Type A logging interpretations and the suggested "generic" vertical placement given in the following subsections. It is recognized that optimal vertical placement of probes where no Type A data exist (e.g., Pit 6) will be approximate, as waste-soil contact information is essentially nonexistent.

2.1 Tensiometers

Tensiometers are used to measure the matric potential[a] of a porous medium under unsaturated conditions or the pressure head if saturated conditions form. Matric potential is used to (1) calculate hydraulic gradients, (2) determine the direction of soil water movement in the vadose zone, and (3) calculate the rate of flow, given the hydraulic conductivity of the materials, determined from laboratory analysis of soil samples or assumed for the material in the waste zone. The EDF-ER-238, "OU 7-13/14 Integrated Probing Project OU 7-13/14 Tensiometer Probe Design," describes the construction and design specifications of the tensiometers installed for this investigation. Very specific elements were incorporated into the design of these tensiometers to mitigate concerns with open radiological pathways that would have been a concern with standard tensiometers.

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a. The field (potential) describing the forces acting on soil water, independent of chemical and gravitational potential, that causes water to move through the soil.

Essentially, these tensiometers are long cylindrical tubes with a porous stainless steel section (0.2-μ pore size) connected to a drive point at the bottom for penetration through the soil and waste. The tube is separated into two different compartments or reservoirs (i.e., upper and lower). All sensors are carried with the instrument when installed.

The tensiometer has three tubing connections and two pressure-sensor wire leads. Two of the tubing connections are pneumatic air lines, which operate a series of filling and calibration spool valves. The two sensor leads are for pressure sensing of the lower porous reservoir and the surrounding soil by the instrument. The two pneumatic air lines are used for operation of the three spool valves. Maintenance (i.e., periodic addition of water) is required to be performed on the instrument to keep it operating correctly. Water is added to an upper reservoir (500-mL capacity) by evacuating the upper reservoir with a vacuum pump and then allowing water to be pulled back into the reservoir from a source at the surface. Water must be transferred from the upper to lower porous reservoir (65-mL capacity) by cycling a valve that separates the two reservoirs. Calibration of the sensors must also be performed on an as-required basis. Calibration is supported by cycling the other two spool valves.

Essentially, three operations can be performed from ground surface on the instrument. These operations include (1) filling the upper reservoir with water, (2) transferring water from the upper to the lower reservoir, and (3) checking the calibration of the two pressure sensors. There are no serviceable parts on the tensiometer from ground surface. Operations and maintenance of the tensiometer will be performed in accordance with TPR-1763, "Type B Tensiometer Operations and Maintenance (inactive)."

When the tensiometer is placed in unsaturated soil, water in the reservoir equilibrates with the soil water in the surrounding medium. During equilibration, which may require several days, water will be drawn from the reservoir through the porous steel and into the surrounding formation and a change in pressure head will occur in the tensiometer. The pressure transducer will measure the vacuum in the air and water column within the tensiometer, which is in equilibrium with the surrounding medium, to determine the matric potential of the surrounding medium.

The following items are functions of these tensiometers or the monitoring networks they support:

- Indication of the moisture state and its variability, spatially and temporally, within the waste zone
- Quantification of the amount and timing of infiltration through the waste zone
- Determination of the amount and lateral extent of the development of perched water toward the bottom of the waste zone.

During this investigation, each tensiometer will be bundled (i.e., placed as close together as possible) with two other tensiometers and a tripled (three sensors) soil moisture probe (described below). This will be considered a localized moisture-monitoring network. The tensiometers will generally be placed as close as possible to the following three vertical horizons:

- Overburden and waste contact
- Upper third of the waste zone
- Waste and underburden contact.

Because tensiometers measure negative pressure head under unsaturated conditions, it is advisable to offset other instruments that would affect these measurements. The suction lysimeters described below can affect local conditions surrounding tensiometers to the point that a response could be measured at the tensiometer when a vacuum is applied to the lysimeter during water sample collection. In an extreme condition, the vacuum applied to the lysimeter could cause removal of the fluid contained in the porous cup of the tensiometer. Prior experience indicates that probes should be installed to maintain an offset of at least 2 ft (0.6 m) between tensiometers and lysimeters installed in the same vertical horizon to mitigate these conditions.

2.2 Soil Moisture Probes

The soil moisture probe indirectly measures the moisture content of soil using the relationship between the soil dielectric constant and the moisture content. The soil moisture content is determined by measuring the frequency shift of a high-frequency excitation signal as it passes through the soil. The probe can also perform resistivity surveys of the profile to measure the electrical contrasts between different geologic mediums and to measure temperature of the surrounding material.

The soil moisture probe module, which is being purchased commercially, is attached behind a drive point. The soil moisture electrodes are included as one of the sections of casing above the conical tip. In an ideal situation, three moisture probe sensors are attached to each probe for this application. When the soil moisture probe is the first probe being installed in an area, two probes may be installed instead of the ideal situation in which only one probe is installed, allowing a probe with a single sensor to be installed first to "tag"[b] the waste underburden contact. Following the first probe installation, a "doubled" or two-sensor probe could be installed. Installing two probes will substantially mitigate scenarios in which sensors are installed closer to the surface than planned because refusal (i.e., the probe would not continue penetrating) was encountered at a shallower depth than anticipated.

The soil moisture probe is connected with a wire lead to a data logger where measurements are stored and downloaded periodically. The tube is sealed so there is no pathway from the sensing element to land surface. Only the data logger will be accessed for downloading. The EDF-ER-234, *OU 7-13/14 Integrated Probing Project Soil Moisture Instrumented Probe*, describes the specifications of the soil moisture probes installed for this investigation. The sensor depths are planned and installed in the probe prior to driving it into the ground. The assembly is pushed from ground surface to the planned depths. The sensors will generally be placed as close as possible to three vertical horizons and, with the exception of the middle moisture sensor, will be similar to the tensiometer porous cup placement. The three vertical horizons include:

- Overburden and waste contact
- Middle of waste zone
- Waste and underburden contact.

The reason for the difference in vertical placement between the middle tensiometer and middle sensor in the soil moisture probe is to maximize the amount of moisture-related monitoring coverage that could be done with the limited budget for probes. Project personnel determined that the effect of increased vertical coverage outweighed the results of not nesting the middle tensiometer and moisture sensor together, as had been originally planned.

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b. Tag: A slang term commonly used in the drilling industry to denote identification of a point of interest in the subsurface. "Tagging" the contact, in the context of this plan, is placing a probe at the desired depth.

2.3 Lysimeters

Suction lysimeters are designed to collect soil water samples under either saturated or unsaturated conditions. To collect water, a partial vacuum is applied on the porous section of the lysimeter (porous stainless steel with a 0.2-μ pore size) that is in contact with the soil, and soil water is drawn into the lysimeter body. Water is removed from the suction lysimeter by applying positive pressure to the suction lysimeter, which pushes the collected water up a tube to the surface and into a sample container. The amount of water collected and duration of collection are dependent on the (1) available soil moisture, (2) soil water potential, (3) conductivity of the porous material in the lysimeter, and (3) vacuum applied. The sample volume is also limited to 1 L, the volume of the collection reservoir.

The push suction lysimeter used for the integrated probing project will be approximately 2.5 in. (7 cm) in diameter. The outside portion of the push suction lysimeter will be the same as the push tensiometer and will consist of a long cylindrical tube with a porous stainless steel section attached to a drive point at the bottom for penetration through the soil and waste. A pipe connects to the porous steel section and provides a conduit and protection for air lines and water lines that extend to the surface. The water line extends from the bottom of the lysimeter point to the surface. The air line is above the water reservoir and also extends to the surface. To operate the lysimeter, the water line is closed and a vacuum is applied to the lysimeter via the air line. When the desired vacuum is achieved, the valve on the lysimeter is closed off to hold the vacuum in the lysimeter reservoir. The lysimeter collects the soil water, decreasing the vacuum as water moves into the reservoir. The EDF-ER-236, "OU 7-13/14 Integrated Probing Project Type B Probes Lysimeter Probe Design," describes the construction and design specifications of the suction lysimeters installed for this investigation.

During installation, lysimeter bundles will generally be placed as close as possible to the following two vertical horizons:

- In or just below the targeted waste for that area
- Waste and underburden contact (or as deep as contact) with underlying basalt if higher moisture zones are probable.

Sample collection and analysis from lysimeters are discussed in later sections.

2.4 Vapor Ports

Commercially available vapor ports are being used to sample soil gas from the waste zones and the area surrounding the soil vaults in the SDA. The probe is pushed into place and will be left as a permanent installation. After installation, the sample tube is terminated at ground surface with a fitting so the port can be accessed. The EDF-ER-235, "OU 7-13/14 Integrated Probing Project Vapor Port Instrumented Probe," describes the specifications of the vapor ports installed for this investigation. Two "filters" are incorporated to prevent larger particles from entering the probe sample chamber. The outer "filter" is a 254-μ stainless steel perforated cylinder. The inner filter is a 38-μ stainless steel screen attached directly behind a drive tip. Soil-gas samples will be collected above ground by applying a vacuum to the vapor port line.

During this investigation, each vapor port will be bundled (i.e., nested) with two other vapor ports. The bundled vapor ports will generally be placed as close as possible to the following three vertical horizons:

- Just below the overburden and waste contact.
- Middle of waste zone, or in close proximity to a desired source.
- Just above (approximately 8 in. [20 cm], if possible) the waste and underburden contact. Ideally, this probe will be placed just above where perched water, if present, would cause the probe to be ineffective for its intended purpose.

2.5 Visual Probes

Visual probes consist of Lexan tubes that allow visual logging devices (e.g., video cameras) to be lowered down through them to allow direct visual examinations of the environment in and beneath the waste zone. The Lexan tubes are resistant to chemical attack. Being able to visually inspect the tubes and their integrity allows the unique opportunity to monitor the status of the tubes and to plan to abandon them in place should they appear to be approaching failure. The EDF-ER-237, "OU 7-13/14 Integrated Probing Project Type B Visual Probe Design," describes the construction and design specifications of the visual probes installed for this investigation.

2.6 Geochemical Probes

Geochemical probes will be used to monitor pH, oxidation-reduction potential, and temperature in the subsurface of the SDA. These probes are currently under development. They are expected to be usable only under saturated conditions, and the lifetime of the probe may be limited to 1.5 years.

3. SAMPLING OBJECTIVES, LOCATION, AND FREQUENCY

This section details the objectives, location, and proposed sampling frequency of Type B probes installed in the SDA. High-level sampling objectives, analytical suites, and general sampling locations (e.g., focus areas) were previously presented in the Probehole Plan. Transects (i.e., horizontal positioning of probes over a relatively straight line) of Type A probes were proposed for the focus areas in the Probehole Plan and subsequently installed and logged between the summer of 2000 and the spring of 2001. Specific placement of Type B probes was dependent upon the results of Type A nuclear logging efforts. This FSP uses results gained from the logging to locate specific clusters of Type B probes but does not go back and reiterate reasons for selecting the general focus areas.

This FSP is designed to provide a framework for sampling operations but cannot predict exact specifications in every case. Minor deviations from the specifications in this FSP that do not affect health and safety can be made without revising this FSP. However, concurrence on the change must be reached between health and safety and project personnel, and the justification and concurrence (e.g., change caused by field conditions or programmatic requirements) must be recorded in the sampling logbook or other appropriate report. If a change to a work control document (such as a technical procedure [TPR] or a radiological work permit) is necessary, work may not proceed until the change is made to the work control document.

Data gaps were identified and investigations to fill those gaps were specified to be included in the OU 7-13/14 RI/FS as part of the Interim Risk Assessment and Work Plan Addendum for OU 7-13/14 (DOE-ID 1998). Because changes in the OU 7-10 scope impact those planned investigations, data needs have been reevaluated. This reevaluation looked at more recent information and focused on data gaps that could impact the choice or cost of any remedial action selected for the SDA. A preliminary set of data quality objectives was identified and will be used to guide the remedial investigation. Feasibility study data needs will be addressed via treatability studies, which are outside the scope of this investigation. The subset that can be achieved through the integrated probing project is addressed by this investigation.

The largest uncertainty identified qualitatively in the Interim Risk Assessment was the source release modeling. Sampling and direct measurement with instrumented probes within the waste zone is one way to acquire contaminant release data and reduce this uncertainty. Four principal data gaps will be addressed by the integrated probing project, as identified in the 1999 Probehole Plan (Becker et al. 1999) and the Waste Area Group 7 Operable Unit 7-13/14 Data Quality Objectives Report (Day et al. 2001). These are (1) infiltration through the waste, (2) release rate and solubility of uranium, (3) release rate of C-14, and (4) mass of VOC source remaining. These four gaps are further described below:

- How much water infiltrates through the waste, and do local saturated conditions enhance contaminant release? Both of these questions help answer if there is a driving force for contaminant movement. Currently, all infiltration monitoring has been done in areas outside the waste so that the modeling uses infiltration rates for subsurface conditions that differ from the waste zones. Shakofsky (1995), in an investigation of infiltration into a simulated waste trench just north of the SDA, observed there was a likelihood of increased infiltration in a disturbed setting. Changes in the prescribed infiltration rate used in the flow and transport modeling could have a large impact on the predicted concentrations and risks, and could impact which contaminants need remediation. Infiltration through the waste affects all of the other data gaps and, in large part, will drive the remedy selection process. Contaminant movement is dependent on the moisture content and the timing and amount of infiltration. The moisture content also controls the corrosion rate of any metal container and the eventual release from the waste form.

- Does a VOC source mass remain? Uncertainties in the mass of VOC released from the waste to the atmosphere preclude an accurate estimate of the mass remaining in the source. The remedy selected for the comprehensive record of decision (ROD) will have to be compatible with the mass remaining, or the VOC mass will have to be removed. In addition to the nuclear logging already performed, collection of VOC samples from vapor ports within the waste should yield an indication of whether significant quantities of VOCs remain.

- What are the physical and chemical forms of the uranium waste, and is uranium waste migrating from the original source? Conservative assumptions about the form of disposed uranium were used in the Interim Risk Assessment, resulting in predicted health risks from uranium. The validity of these assumptions will be evaluated using, in part, leachate samples collected from known uranium disposals in the SDA.

- How rapidly is C-14 released to the environment and in what form? Most of the C-14 is in activated metals or beryllium blocks. The lack of site-specific data causes uncertainties in the release rate for C-14. Conservative assumptions used in the Interim Risk Assessment show a potential health risk from C-14. The validity of these assumptions will be evaluated using both water and vapor samples collected from known C-14-bearing waste disposals in the soil vaults in the SDA.

3.1 Analytical or Data-Gathering Approach

3.1.1 Data-Gathering Approach for Tensiometers

The objective in placing tensiometers (and moisture sensors, as discussed below) is to obtain both qualitative and quantitative information on the amount of water contacting waste in the pits. The objective in placing these instruments is to obtain this information both at the three primary targeted waste locations identified during the Type A investigative activities and at other representative locations. Other locations include placement (1) in slight surface depressions, (2) in slight surface high spots, (3) near ditches, (4) in areas where the undulating basalt surface results in local depressions that could lead to development of perched water, and (5) at some other locations (e.g., SVRs) described later in Section 3.

Two major classes of locations for tensiometer installation are identified as (1) targeted waste locations, and (2) ditch influence locations. These latter locations may be adjusted to include surface depressions identified just prior to installation (i.e., from localized settlement). Thirty tensiometer probe bundles[c] (90 probes) are planned for installation in support of this investigation. This number was determined subjectively by considering cost, data management and analysis requirements, and adequacy of coverage for determining infiltration. At each individual location, three drive-point tensiometers will be installed to enable quantitative determination of matric potential gradient information.

Upper basalt surface topography data (see Figure 3) indicate a possibility of lateral movement of saturated water toward Pits 4 and 10 from both the north and the south. Interpretive arrows are superimposed on the figure to show likely areas where water would accumulate. Data control points for the basalt surface topography are generally much sparser inside Pits 4 and 10 than outside the pits.

c. In the context of this plan, "probe bundle" is used to describe probes planned to be installed as a group. For example, tensiometers are always planned for installation in a group of three (i.e., five bundles of tensiometers would consist of 15 tensiometers).

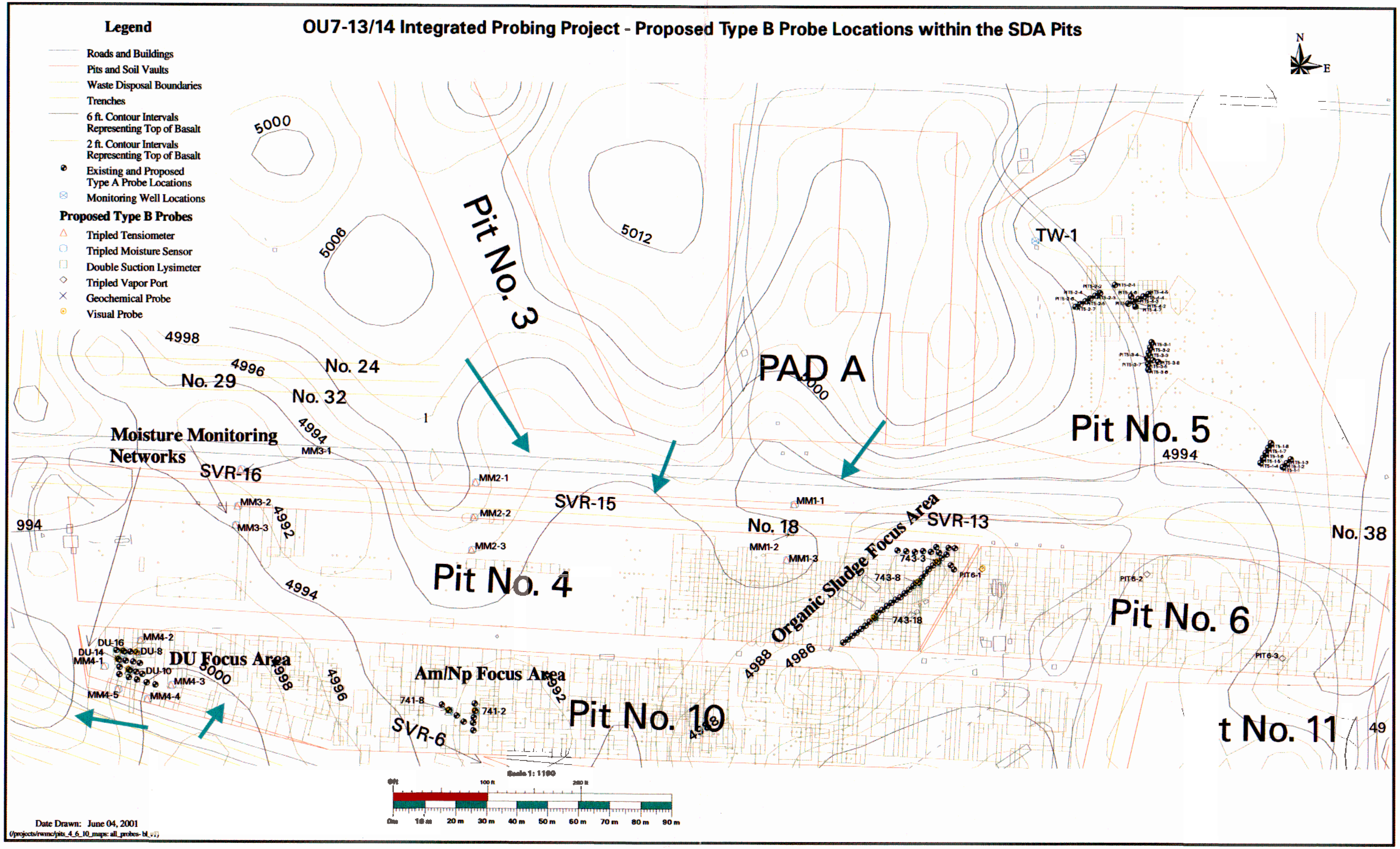

Figure 3. Map showing proposed monitoring locations in pits in the SDA. Also shown are contours of the upper surface of basalt beneath the SDA showing locations where lateral movement of water into waste zones in Pits 4 and 10 may occur.

Figure 4 shows the SDA areas that had significant ponding during the February 1995 melt. This melting and water accumulation pattern was similar to the ponding that occurred in 1993, 1994, and 1996. The figure shows ponding in ditches nearly all the way around the perimeter of Pits 4, 6, and 10. Some monitoring locations will be located to determine the extent of lateral movement away from these ditches into the waste zone. Three transects of instruments located on the north side of Pit 4 are indicated for this purpose, and one area, containing five bundles of tensiometers, is located in Pit 10 for the same purpose.

The tensiometer pressure transducer is connected to a data logger where measurements are stored and periodically downloaded. Initial measurement frequency will be approximately every 2 hours, and data will be downloaded at regular intervals. Measurement frequency may decrease after several months, depending on the potential for infiltration. If the potential for infiltration is low, measurement frequency may decrease to something on the order of every 6 hours. As potential for infiltration increases (e.g., snow melt or standing water in ditches), measurement frequency may also be increased. Precision and accuracy of the advanced tensiometer, upon which the design of the push tensiometer is based, is within ±4 in. (±10 cm) of water, which applies to both the soil underburden and soil within the waste.

Single-point (one per vertical profile) tensiometers will yield matric potential measurements that will be used to determine changes related to infiltration or drainage in moisture state over time, and to determine the extent of infiltration, depending on the depth of tensiometer placement.

Two or more appropriately positioned nested tensiometers will provide measurements that will be used to calculate gradients to determine direction of water flow, and to quantitatively estimate net infiltration through the underburden into the underlying basalt (assuming the hydraulic conductivity of the underburden) based on existing laboratory data from surrogate soil samples. Confidence in net infiltration estimates will be heavily dependent on the hydraulic conductivity used for the underburden.

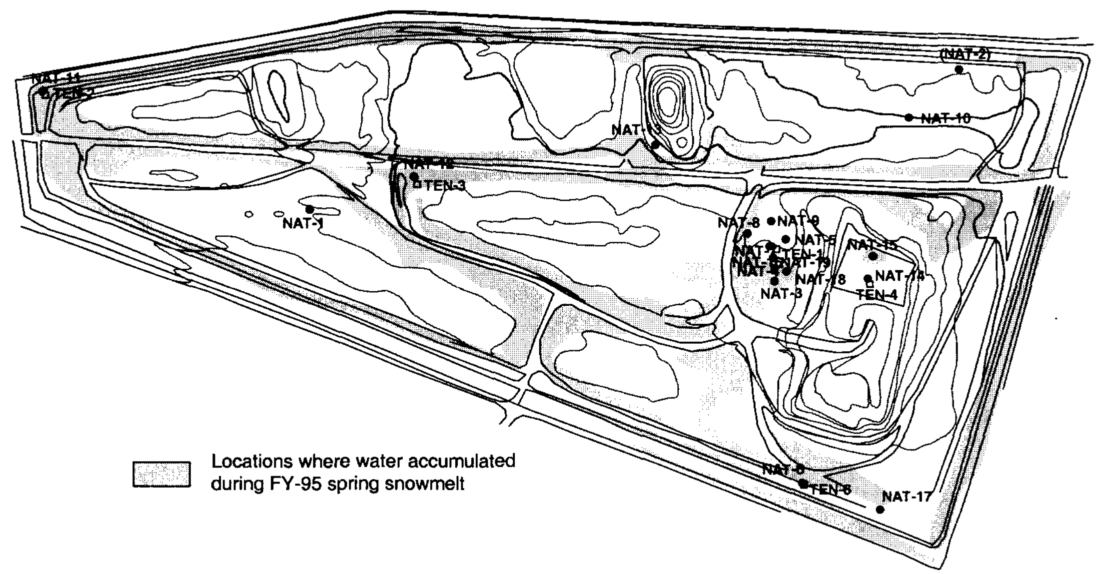

Figure 4. Locations at the Subsurface Disposal Area showing significant ponding during February 1995 (Bishop 1996).

3.1.2 Data-Gathering Approach for Soil Moisture Probes

The soil moisture probes will be capable of measuring moisture content at up to three elevations in each probe. These probes will always be bundled with nested tensiometers to ensure comparability of data in terms of location. Moisture content measurements cannot be calibrated to the waste or interstitial soil. However, relative changes in moisture content (i.e., decreasing or increasing values) will indicate infiltration or net drainage of water. Moisture content measurements within the underburden soil are expected to exhibit a precision and accuracy of ± 8% moisture content. The long-term precision and accuracy of these instruments (i.e., beyond 3 months) have not been proven in the field. The measurement frequency made by the soil moisture probes will closely follow that established for the tensiometers.

Moisture content sensors will yield soil moisture measurements that will be used to determine the following items:

- Relative changes in moisture over time, related to infiltration or drainage. These will corroborate and supplement matric potential measurements from tensiometers.
- Extent of infiltration, depending on depth of probe placement. These will corroborate and supplement matric potential measurements.
- A lower bound on the order of magnitude for net infiltration and drainage at the depth of the probe. The accuracy of the moisture content measurements is expected to be higher in the soil underburden than within the waste.

The measurements of matric potential from the tensiometers to determine direction of flow, along with concentrations of contaminants from water samples (collected from lysimeters) and changes in water content (e.g., drainage), are combined to provide an estimate of contaminant flux rates in the vadose zone. The soil moisture probes will also be used to measure temperature in the surrounding soil. These data will be used as input to source term release modeling applications.

3.1.3 Data-Gathering Approach for Lysimeters

Because of uncertainty regarding radionuclide concentrations in the water recovered from the lysimeter and in the retrievable sample volumes, the first round of analyses is expected to be conducted at the INEEL radiochemical laboratories located at the Test Reactor Area (TRA) and the Idaho Nuclear Technology and Engineering Center (INTEC). This FSP outlines various sampling and analysis requirements to support onsite analysis of these water samples. After the radiological content of the samples is baselined, samples may be sent to approved offsite analytical laboratories. If other laboratories are used, analytical methods, including sample size and preservation, may differ from those specified in this FSP. As long as the analyses are in accordance with an INEEL Sample Management Office (SMO)-approved task order statement of work (SOW), minor changes will not require a modification of this FSP.

Water samples are being analyzed for two different analytical suites under this FSP, depending on origin. Samples collected from the pits will be analyzed in accordance with the analytical suite shown in Table 1. These are essentially the current OU 7-13/14 prioritized analytes (DOE-ID 1998) specified by the Probehole Plan. Concentrations over time will yield information on trends that will be compared to the source term modeling done for the OU 7-13/14 RI/FS. Although there may not be data available to support source release modeling improvements prior to initiation of the RI/FS, some monitoring data will be available to support the modeling prior to the ROD. Additionally, the monitoring data will be very useful in evaluating the appropriateness of the source term model in the 5-year review cycle after the ROD. The source term model chosen to support the OU 7-13/14 RI/FS is the Disposal Unit Source Term (DUST) model (Sullivan 1993). Water samples collected near the activated stainless steel in soil vaults will be analyzed in accordance with the suite identified in Table 2.

Table 1. Required detection limits and support information for Type B lysimeter samples collected from the Subsurface Disposal Area pits.

Analyte	Required Detection Limit (pCi/L or mg/L)	Approximate Count Time (minutes)	Minimum Sample Volume	Field Preservative and Bottle	Methods	Onsite Laboratory	Priority
Gamma-emitting radionuclides	<200 (Cs-137)	TBD but 1,000 minutes likely due to low RDL (required detection limit)	50 mL	HNO_3, pH <2 1-L fluorinated HDPE (high-density polyethylene) or Teflon	GMS (gamma spectrometry)	Idaho Nuclear Technology and Engineering Center (INTEC)	1
Am-241	<2	480	Combine with gamma		ALS (alpha spectrometry)	INTEC	
Pu-238	<2	480	Combine with gamma		ALS	INTEC	
Pu-239	<2						
Pu-240	<2						
U-234	<2	480	Combine with gamma		ALS or ICP/MS (inductively coupled/mass spectrometry)	INTEC	
U-235	<2						
U-238	<2						
Np-237	<2	480	Combine with gamma		ALS	INTEC	
Tc-99	<15	480	Combine with gamma		LSC (liquid scintillation) or GFP (gas flow proportional)	INTEC	
C-14	<50	480	40 mL	HDPE	LSC or GFP	Test Reactor Area (TRA)	2
I-129	<40	480	50 mL	Amber glass (6-month hold time) HDPE (28-day hold time)	LEPS (low-energy photon scintillation)	INTEC	3
H-3	250	480	20 mL	HDPE	LSC	INTEC	4
Nitrate and nitrite	ER-SOW-394	N.A.	15 mL	4°C Note 48-hour hold time 30-mL HDPE		INTEC	5
Appendix IX metals (without mercury)	ER-SOW-394	N.A.	50 mL	4° C Combine in 1-L gamma spec bottle		INTEC	6
Appendix IX VOA (volatile-organic analysis)	ER-SOW-394	N.A.	20 mL	H_2SO_4, pH <2, 4° C, no headspace, 20-mL VOA vial	GC/MS (gas chromatography/ mass spectrometry)	INTEC	7

Table 2. Required detection limits and support information for Type B lysimeter samples collected from soil vaults containing activated metal.

Analyte	Required Detection Limit (pCi/L or mg/L)	Approximate Count Time (Minutes)	Minimum Sample Volume	Field Preservative/Bottle	Methods	Priority
Gamma-emitting radionuclides	<200 (Cs-137)	TBD but 1,000 minutes likely due to low RDL	50 mL	HNO_3, pH <2 1-L fluorinated HDPE or Teflon	Gamma spectrometry (GMS)	1
Tc-99	<15	480	NA (use of gamma spec sample)	Combine with gamma (use gamma sample after gamma analysis)	Liquid scintillation (LSC) or gas flow proportional (GFP)	
C-14	<50	480	40 mL	HDPE	LSC or GFP	2
H-3	250	480	20 mL	HDPE	LSC	3
Ni-59	400	1,000	50 mL	Combine in 1-L bottle with gamma	LEPS, GFP, or LSC	4
Ni-63	50	300	50 mL	Combine in 1-L bottle with gamma	LEPS, GFP, or LSC	5
I-129	<40	480	50 mL	Amber glass (6-month hold time) HDPE (28-day holding time)	LEPS	6
Appendix IX metals (without mercury)	ER-SOW-394	N.A.	50 mL	4° C Combine in 1-L bottle with gamma		7

Water samples are expected to be collected quarterly from lysimeters, with flexibility to change the frequency, as needed. The amount of water collected and duration of collection are dependent on the available soil moisture, the conductivity of the porous material in the lysimeter, and the level of vacuum applied. The TPR-1674,"Glove Bag Supported Sample Acquisition from Type B Probes in the SDA," contains the lysimeter sampling procedure and gives limits for the amount of vacuum that should be applied. The time required to collect a sufficient sample following placement of a vacuum on the probe is expected to be approximately 7 days. However, waiting too long could allow for the collected sample to be drawn back to the formation, while not waiting long enough could minimize the volume of the sample that would have otherwise been available for collection. The optimum time required between application of the vacuum and collection of the sample is expected to vary between lysimeters and season of the year. Judgment gained through several rounds of sampling will be used to further optimize this time period.

Note: Exceeding the stated limit may severely compromise the lysimeter, as water in the porous steel could be drained and allow air to pass through (making it inoperable).

Opportunistic samples may also be collected, as required by future programmatic needs. This may include samples for currently unspecified analysis (e.g., hexavalent chromium, depending on total chromium results). In such cases, the analyses will be identified by the task order SOW issued by the INEEL SMO. Appendix B contains the SMO sample plan tables for the first round of samples collected during this investigation.

If insufficient sample volume is collected to analyze all constituents identified in the tables, the analytical priority listed in the column on the right hand side of the tables will be used as a guide for prioritizing analyses. Project objectives and analysis performed during a previous round of sampling may alter the priority in the table(s). To make the lysimeter functional, the porous stainless steel screen is required to be saturated with water during installation. This added water will have an adverse consequence. It will cause slight dilution of the initial samples until this small amount of water is completely replaced with the surrounding formation water. This is an unavoidable consequence when first sampling lysimeters.

The installation procedure, TPR-1672, specifies that non-INEEL water will be used for the saturation step. This will mitigate potential tritium contamination from non-SDA based INEEL sources.

3.1.4 Data-Gathering Approach for Vapor Ports

Three different analytical parameters have been identified for analysis of vapor port gas samples, depending on sampling origin. Vapor port samples, collected in the pits, will be analyzed for VOCs. Samples collected from vapor ports near the SVRs will be sampled for C-14 or C-14 and tritium, depending on origin.

3.1.4.1 Volatile Organic Compound Samples Collected from Vapor Ports Located in the Pits. In accordance with the strategy developed in the Probehole Plan, a multigas monitor (i.e., Brüel & Kjaer [B&K] photoacoustic analyzer) was suggested for VOC analyses of vapor samples collected from the pits. The VOCs identified for analyses were carbon tetrachloride (CCl_4), trichloroethene (TCE), chloroform ($CHCl_3$), 1,1,1-trichloroethane (TCA), and tetrachloroethene (PCE). These are the same chlorinated VOCs being monitored in the soil gas surveys performed in support of the OU 7-08 organic contamination in the vadose zone (OCVZ) project.

Using an approach similar to that adopted by the OCVZ project is preferable from a cost perspective, and will ensure comparability of data by using similar methods and analytical suites. Essentially, the vapor-phase VOCs being monitored as part of the Type B probing project are from the same source as the VOCs sampled during the soil-gas surveys supporting the OCVZ project. The difference is that the samples collected from Type B vapor ports will be collocated within the waste (i.e., either in or around), while the samples collected in support of the OCVZ project have been from collection points in the overburden soil or in monitoring wells located outside of the pits (i.e., outside the waste).

Either the B&K Model 1302 photoacoustic multigas monitor currently in use in support of the OCVZ project, or the updated INNOVA[d] Model 1314 photoacoustic multigas monitor is expected to be the primary instrument used for VOC vapor analyses. The measurement principles of these instruments are based on the photoacoustic infrared detection method. The instruments can measure almost any gas that absorbs infrared light (e.g., most chlorinated VOCs). Up to five optical filters are installed in the unit's carousel to enable selective analysis of up to five compounds at a time. The units compensate any measurement for temperature fluctuations, water-vapor interference, and interferences from other gases known to be present.

d. When B&K was split up in the 1990s, INNOVA was tasked with all B&K gas monitoring equipment development.

A wide range of narrow-band optical filters is available from the instrument supplier. The selectivity of the analysis is determined by selection of these narrow-band filters. Filters are selected by studying the absorption spectra of the gases to be monitored, as well as those of any other gases found in the same air being monitored. The vendor supplies a gas detection limits chart to aid in the filter selection, and also supplies expert assistance. The gas detection limits chart and support provided by the vendor were used to select the filters for the Type B investigation.

Water vapor, which is almost always present in ambient air, absorbs infrared light at most wavelengths so that regardless of which optical filter is used, water vapor will contribute to total acoustic signal in the analysis cell. A special optical filter, permanently installed in the unit, allows water vapor contribution to be measured separately. The instrument then automatically compensates for the water vapor interference. One of the main limitations of the technology is that most organic gases absorb energy over a wide range of the infrared spectrum, making measurements susceptible to interferences. The unit allows for compensation of known interferences, however, sample matrices with unknown interferences could result in erroneous measurements (EPA 1998). By installing an optical filter to selectively measure the concentration of the interferent gas, the user can set up the instrument to compensate for the interferent gas contribution.

The VOC samples are expected to first be collected on a quarterly basis. After a baseline is established, sampling frequency may be reduced and will be determined at a later date.

3.1.4.2 Optical Filter Selection. Immunity to interfering species is an important consideration to mitigate interference during analysis. Concentration and type of potentially interfering gases are important aspects in optical filter selection. As a result, previous analytical data from the soil gas surveys around the SDA were evaluated to support selection of optical filters. Table 3 shows the compounds of interest, maximum concentrations detected for those compounds from soil-gas monitoring in the SDA (1998 survey at Pit 4), and the recommended optical filters and their corresponding analytical detection ranges. Appendix C contains a more complete evaluation of the optical filters selected and the corresponding errors that are anticipated from this selection.

Note: Other parameters may be evaluated with additional instruments or a change in optical filter selection. A change to the instrument's optical filters would typically require that the instrument be sent back to the manufacture's representative for calibration and testing.

Table 3. Compounds of interest, maximum concentrations detected from soil gas monitoring, and recommended optical filters.

Name	Formula	Molecular Weight	Maximum Concentration (ppm)	Optical Filter	Range (ppm)
Carbon tetrachloride	CCl_4	153.80	7,260.0	UA 0936	6 to 100,000
Chloroform	$CHCl_3$	119.40	1,550.0	UA 0971	1 to 10,000
1,1,1-Trichloroethane	$C_2H_3Cl_3$	133.40	208.0	UA 0974	0.09 to 9000
Trichloroethene	C_2HCl_3	131.40	1,590.0	UA 0975	0.3 to 10,000
Tetrachloroethene	C_2Cl_4	—	78.5	UA 0976	0.04 to 4000

The photoacoustic infrared monitor will be operated in accordance with the manufacturer's instruction manual (i.e., INNOVA or B&K, as appropriate). Quality assurance (QA) requirements associated with these samples are included in Section 5.4.2.

3.1.4.3 Carbon-14 Samples Collected from Vapor Ports Located Near the Soil Vault Rows. Carbon-14 sampling develops a baseline of data for the concentration of C-14 in the carbon (as C-14 Ci/g C) present as CO_2 in the soil gas. Carbon-14 may be collected using an existing method consisting of gas washing bottles (i.e., bubblers) filled with a base solution. $^{14}CO_2$ is trapped in the base-filled bubblers. The TPR-1633, "Soil Gas Sampling for Tritium and C-14 with Gas Washing Bottles," describes the procedure for preparing and collecting these samples. A new procedure that does not involve the use of caustic base material in the field may be developed to replace TPR-1633. In the event that programmatic funding limitations do not limit sampling, C-14 samples are expected to be collected quarterly from the vapor ports installed near SVRs. After a baseline is established, sampling frequency is expected to be reduced and will be determined at a later date.

3.1.4.4 Tritium Samples Collected from Vapor Ports Located Near the Soil Vault Rows. The tritiated soil gas sampling system that will be established at SVR-20 consists of a vacuum pump, control unit, and glass moisture traps. It collects soil-gas samples drawn from the vapor port probes installed around the SVR-20 monitoring location. The purpose of this sampling is to detect and measure tritium content in the water vapor extracted from the SVRs. Samples are expected to be analyzed at the INEEL radiation measurements laboratory. The TPR-1771, "Soil Gas Sampling in the Soil Vault Rows," describes the procedure for preparing and collecting these samples. In the event that programmatic funding limitations do not limit sampling, tritium samples are expected to be collected quarterly from the vapor ports installed near SVR-20. After a baseline is established, sampling frequency is expected to be reduced and will be determined at a later date.

3.1.5 Information Sought from Visual Probes

Approximately 13 probes are planned for installation in the pits. While most of the visual probes are located close to the targeted waste areas, several of the probes are located elsewhere for reconnaissance. In accordance with TPR-1671, "Visual Probe Logging Procedure," commercially available video equipment will be used to monitor the visual probes. The images will be recorded on standard videotape. The operator of the video camera will use professional judgment to determine the speed and orientation of the video camera during logging activities. To the extent possible, the visual probes will be used to verify, monitor, or evaluate the following within the waste zones:

- Location of top and bottom of the overburden and underlying sediment
- Thickness of sediment beneath the waste
- Relative grain size (e.g., cobbles, pebbles, sand, silt, or clay) to determine whether clay is on top of the basalt
- Stratification in the sediment beneath the waste or disturbance in the sediment
- Color of sediment beneath the waste for oxidation and reduction indication
- Amount of sediment versus waste adjacent to the tube in the waste zone
- Visual clues about moisture movement in the sediment
- Evidence of how tightly the tube is sealing in the sediment
- Evidence of burrowing animals (e.g., mammals or insects) in the backfill or evidence of root invasion
- Condition of the drums

- Void spaces caused by drum placement or lack of material
- Cellulose material (e.g., boxes, wood, or paper)
- Waste from identification (e.g., sludges, graphite, combustibles, nitrate salts, or noncombustibles).

Following the initial round of video logging and subsequent review, additional, more focused logging activities may be conducted to more fully address evaluation of the bulleted items above. Future video logging activities may be conducted on an as-needed basis. Visual probes are currently limited to spacing these probe types no closer than 5 ft (1.5 m) edge to edge. This criticality control requirement may be modified prior to probe installation.

3.1.6 Data Gathering from Geochemical Probes

Geochemical probes will be used to monitor pH, oxidation-reduction potential, and temperature in the subsurface of the SDA. These probes are currently under development and will be addressed at a later date, either as a revision to this FSP or in other documentation.

3.1.7 Sampling Frequency

This section summarizes the expected sampling frequencies for the data types described in the previous subsections. Table 4 lists these frequencies.

Table 4. Sampling frequencies expected for various probes types.

Probe Type	Data Type	Type Location	Expected Frequency
Tensiometer	Electronic	All	Initially every 2 hours
Soil moisture probe	Electronic	All	Initially every 2 hours
Lysimeter	Liquid water samples	All	Quarterly
Vapor port	Soil-gas samples for VOC analysis	Pits	Quarterly
Vapor port	Soil-gas samples for C-14 and tritium analysis	SVRs	Quarterly
Visual probe	Video log	Pits	Initial video logging and then as needed
Geochemical probe	Electronic	All	TBD

3.2 Grouping Probes by Area of Investigation

This section details the placement of Type B probes in the SDA. It was prepared so that the probe installers could determine what instruments would be installed in each investigation area. It also describes the rationale for selecting the probe cluster[e] location. The primary purpose of the clustering approach, which includes Type A as well as all Type B probes, is that release models can be calibrated by having information regarding the source mass, net infiltration, and leachate concentrations as a function of time.

Typically, clusters of Type B probes are being installed surrounding previously installed and logged Type A probes. Type A probe locations were originally sited based on an evaluation done in the Probehole Plan. This evaluation included a search of disposal records for key waste streams

e. The term "probe cluster" is used to describe the full suite of probes planned for placement around a specific target location (e.g., all Type B probes placed around a specific Type A probe).

(e.g., depleted uranium [DU] and organic sludge). Disposals containing candidate waste were highlighted as an overlay over the pit boundaries using Geographic Information System software. These disposals are typically represented as numbered boxes on probe location figures provided later in this section. Based on the disposal location information and results of previous geophysical and soil-gas surveys, candidate locations were selected to install Type A probes. Results from the nuclear logging of these Type A probes were then used to site Type B probes.

In May 2001, following the initial nuclear logging performed on Type A probes, additional azimuthal or directional logging activities were conducted on selected probes. Essentially, specific zones of interest identified during the first phase of logging were directionally logged in an effort to investigate the spatial distribution of subsurface radionuclides, to select optimal locations for Type B clusters, and to optimize placement of lysimeters within the selected cluster locations.

At the present time, considerable uncertainty exists with respect to funding and probe availability (e.g., final numbers of Type B probes to be installed and additional Type A probing and logging activities). Therefore, the final probe cluster locations and numbers of probes installed are approximate. Depending on funding, additional Type A probes may be placed in arrays surrounding existing Type A probes of interest to support better source mass evaluations. The following subsections list possible probe cluster locations and distribution of probe types within the clusters. Because this initially planned approach may change, final "as built" information will be provided in a final closeout report detailing the probe completion.

Figure 5 represents a cross sectional view of a typical cluster containing one entire suite of probes installed in support of this investigation. Figure 6 represents the same probes from an isometric perspective. The isometric view of the probes indicates a typical arrangement of probes surrounding a target Type A location. Not all probe clusters contain every probe type identified by these figures. Specific clustering of probes is discussed in the sections below. The following investigative areas are discussed:

- Depleted uranium focus area
- Organic sludge focus area
- Americium and neptunium focus area
- Pit 5 investigation
- Pit 6 investigation
- Moisture monitoring network
- Activated metal (stainless steel), SVR-12
- Activated beryllium, SVR-20.

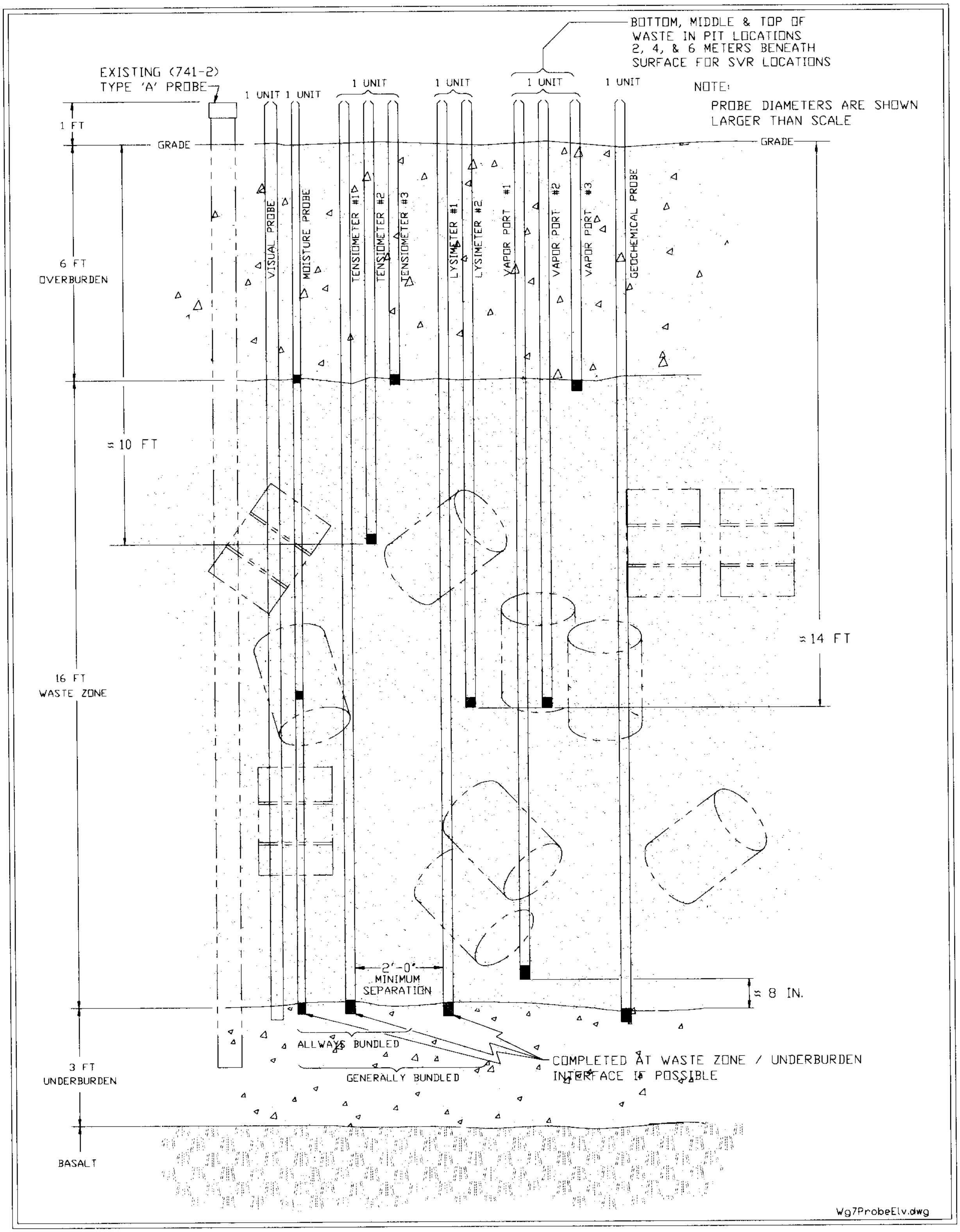

Figure 5. Cross-sectional view of typical Types A and B probe clusters in the Subsurface Disposal Area.

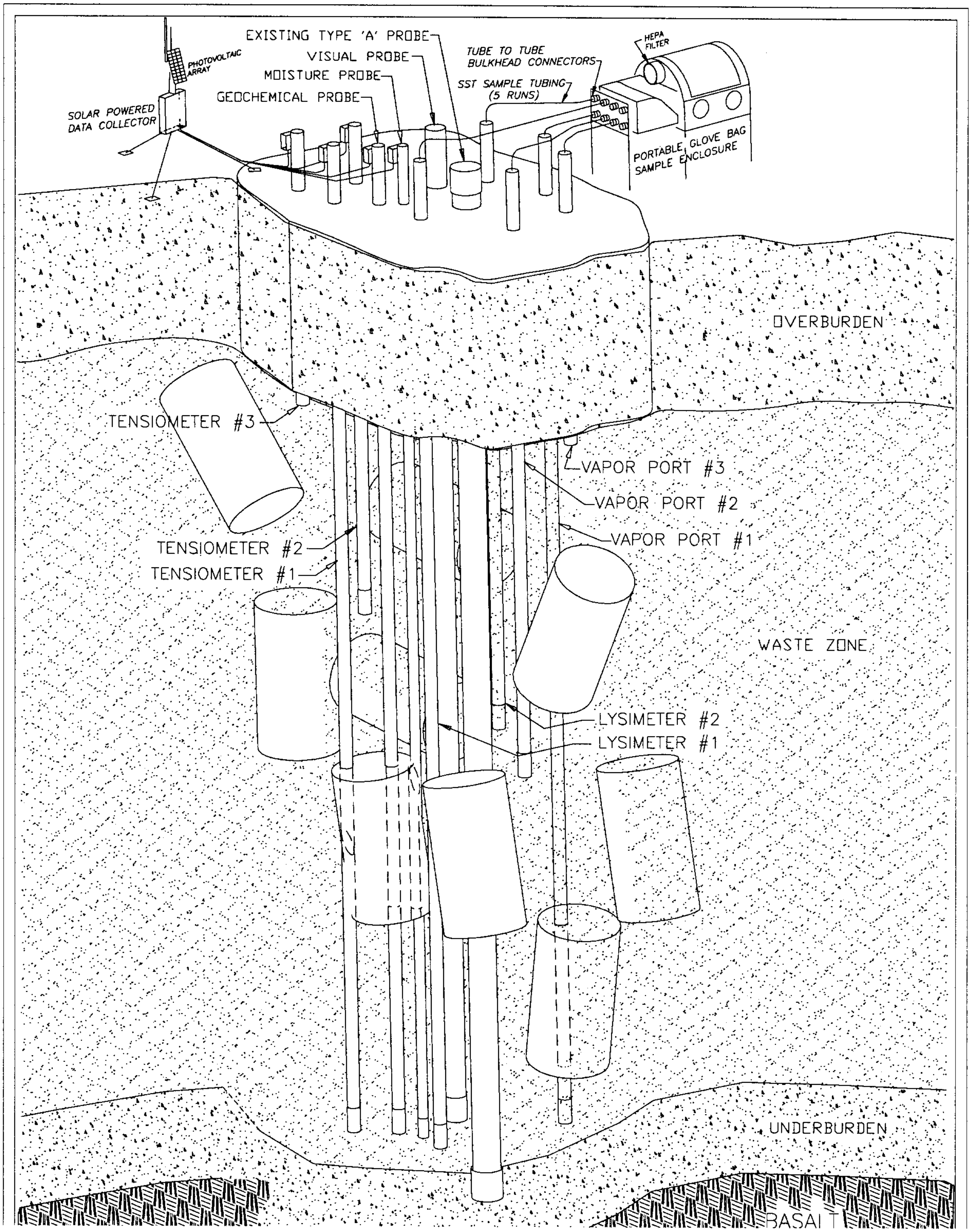

Figure 6. Isometric perspective of typical Types A and B probe clusters in the Subsurface Disposal Area.

3.2.1 Depleted Uranium Focus Area

Most uranium disposed of in the SDA is DU sent from the RFP. Most of the DU was roasted (i.e., oxidized to allow for the safe shipping and storage of the material) to eliminate the potential for a pyrophoric reaction. Review of the shipping records indicated that Pit 10 contains source areas to sample the roaster oxide form of DU, waste type RFO-DOW-16H. Of special interest are Disposals 5 and 15, located in the western portion of the pit (see Figure 7). This waste was among the first disposed of in Pit 10. Disposal 5 contained 153 drums of waste, of which 25 were the roaster oxide form of DU (i.e., oxidized uranium chips and turnings from machining operations). Disposal 15 contained 154 drums of waste, of which 20 drums contained roaster oxides.

This area was chosen for installation and logging of two phases of Type A probes. Factors influencing the selection of these disposals for Type A probehole placement and investigation are described in the Probehole Plan. Table 5 indicates the contents and disposal coordinates for Disposals 5 and 15, which were the target shipments during the Type A investigation and are still the targets for the Type B activities.

Interpreted results from the second phase of Type A probes are given in the letter report, *Summary of DU and 743 Study Area Logging Results through 2/5 w/Emphasis on New Logging Data Received on 1/29/01* found in Appendix D. The highest concentrations of uranium detected in the DU focus area were found at locations DU-10, DU-14 and DU-16. These and other candidate Type A probes from this focus area were subsequently directionally logged at targeted depth intervals in May 2001. Results summarized in the letter report, *Summary of DU and 741 Area Azimuthal Logging, Logging data through 5/23/01* (see Appendix D), indicate that the three locations discussed above are the optimal locations within the DU focus area around which to site Type B probes and collect data on DU characteristics in the SDA. In addition to the three areas described above, an excellent DU source was identified along the organic sludge focus area transect. The highest level of uranium logged in any Type A probe was found at probe cluster location 743-08. This probe was also selected as the origin of a probe cluster to characterize organic sludges and, as such, will serve for both DU and organic sludge characterization.

Finally, a fourth cluster identified in the DU focus area is being investigated because logging results indicated that it was an excellent site to monitor neptunium waste. This site (DU-8) is described in Section 3.2.7, under the americium and neptunium focus area. Letter reports describing the preliminary evaluation of Type A nuclear logging data to support selection of Type B probe cluster locations are given in Appendix D.

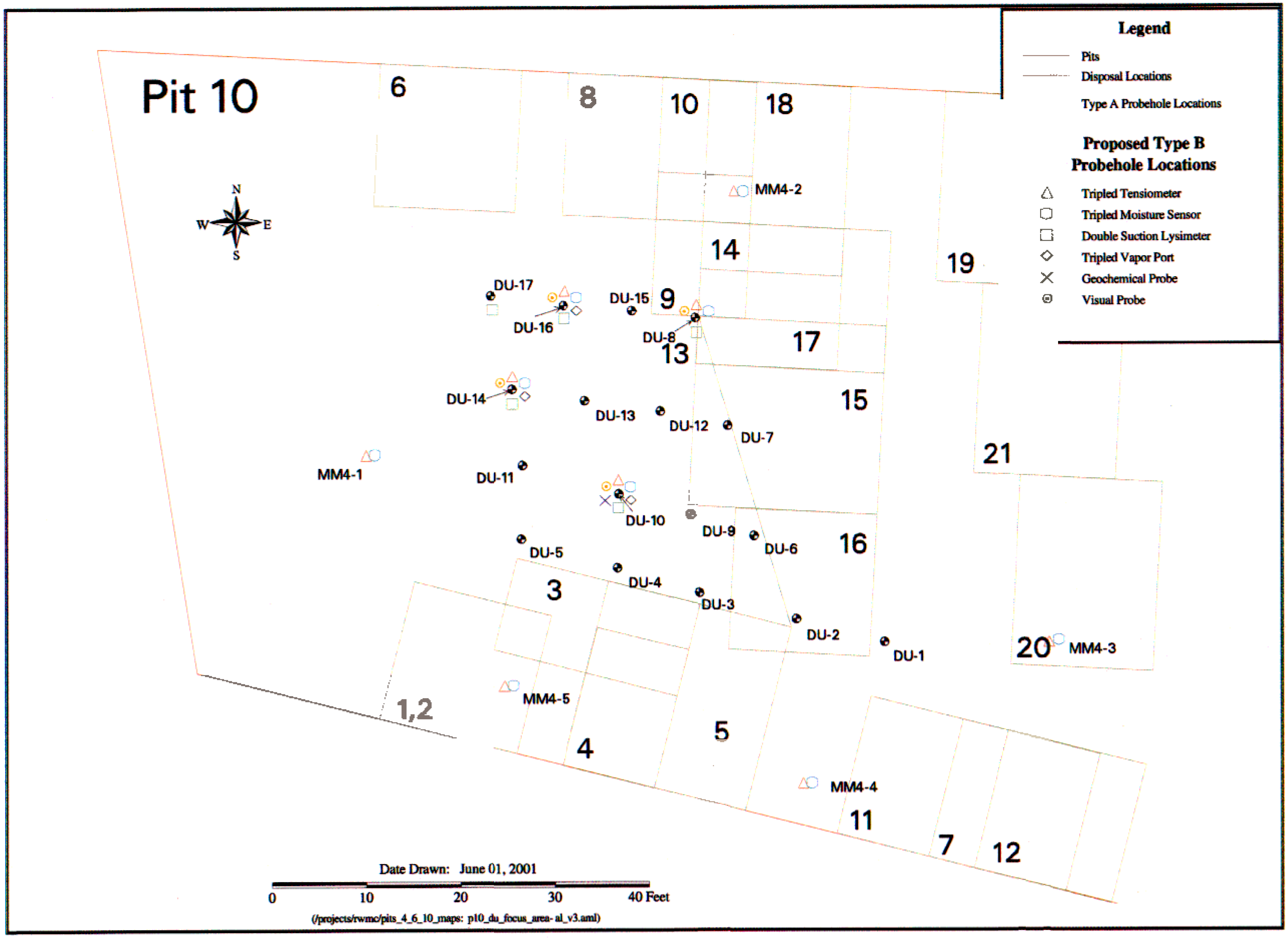

Figure 7. Proposed Type B probe clusters at the depleted uranium focus area.

Table 5. Contents of shipments evaluated for the depleted uranium focus area.

Pit 10 Disposals	Location	Rocky Flats Generator	Description	INEEL Waste Stream Identification	Drum Weight (lb)	Disposal Date
5	40 to 60 ft east and 0 to 20 ft north of S/W monument	44	25 roaster oxide, 52 Type V	RFO-DOW-16H and 9/10H	31,378	8/12/68
		77	60 Type I, 16 Type V,	RFO-DOW-4H, and 9/10H	8,617	8/12/68
15	65 to 85 ft east and 25 to 45 ft south of N/W monument	44	61 Type V, 20 roaster oxide, 2 BE, 71 Type I	RFO-DOW-9/10H, 16H, 31H, and 4H	26,331	9/12/68

The following set of Type B instruments was planned for installation at the DU focus area to monitor uranium-bearing waste, although some of these probes are presently funding limited:

- Three tensiometer and moisture sensor bundles
- Four lysimeter bundles
- Three vapor port bundles
- One geochemical probe
- Three visual probes.

3.2.2 Organic Sludge Focus Area

Organic compounds buried in the SDA include CCl_4, methylene chloride, TCE, TCA, PCE, heavy lubricating oils, traces of polychlorinated biphenyls, chlorofluorocarbons, alcohols, organic acids, EDTA (ethylene-diaminetetraacetic acid, also known as versenes), and nitrobenzene. The primary contributors to potential risk in the Interim Risk Assessment from organic sludges were CCl_4, methylene chloride, and PCE. Carbon tetrachloride, 98% of which was originally contained in waste stream RFO-DOW-15H (also known as organic sludge or 743-series sludge), dominates the present and near-term potential risk. Disposal records indicate that the east end of Pit 4 contains a large number of drums containing 743-series sludge. High VOC soil-gas concentrations have been detected over the east end of Pit 4, corroborating that drums containing 743-series sludge are buried there.

The primary purpose of the Type B investigation in Pit 4 is to continue the evaluation of organic sludge started during the Type A project. A combination of soil vapor probes (both shallow and within the waste), enhanced logging of the Type A probes, flux chamber measurements, and modeling will be used to refine the source mass remaining. During Type A probe activities, a large transect of nuclear logging probes (i.e., Type A probes) was installed in the eastern side of Pit 4. The area investigated contained a significant quantity of organic sludge, as evidenced by disposal records (INEEL 2000). Unlike the other two focus areas, disposal of organic sludge in the northeast end of Pit 4 was ubiquitous, so identification of precise Type B cluster installation locations was not considered critical. The three primary probe clusters selected were chosen to cover a large aerial extent of the transect and also to cover a range of chlorine detections from nuclear logging that, together with soil gas results and disposal information, are believed to be indicative of the presence of chlorinated solvent-containing source material. Appendix E contains the letter reports that summarize the interpretation of the nuclear logging data.

Location 743-3 was chosen to site Type B probes because it had the highest chlorine signature of any Type A probe along the transect and was located in an area known to contain organic sludge disposals, which were supported by soil-gas survey results. Location 743-08 was selected for much the same reason. In addition, this location contained the largest detection of U-238 daughter products. As a result, 743-08 may provide valuable information regarding DU characteristics, in addition to the data to be gained regarding organic sludges. Location 743-18 was selected because it is in the transition area between disposals which contain organic sludges and those which do not. Type A logging data indicated the presence of chlorine, but at substantially lower concentrations than identified at 743-3 and 743-8. The letter reports containing the preliminary evaluation of Type A nuclear logging data used to support selection of Type B probe clusters in this focus area are given in Appendix D. The following set of Type B probes were planned for installation at the organic sludge focus area, although some of these probes are presently funding limited:

- Six tensiometer and moisture sensor bundles
- Four lysimeter bundles
- Five vapor port bundles
- Two geochemical probes
- Five visual probes.

Figure 8 indicates the approximate locations of the three currently funded probe clusters.

3.2.3 Americium and Neptunium Focus Area

The primary source of Am-241 and Np-237 in the SDA is the first stage wastewater sludge (i.e., the 741-series sludge) from Rocky Flats Environmental Technology Site. Pit 10 contains source areas to sample 741-series sludge (i.e., waste stream RFO-DOW-3H). Of special interest are waste Disposals 195, 196, 205, 206, and 207 that contained 741-series sludge. These disposals were investigated because they contain both relatively large numbers and high ratios of 741-series sludge compared to other waste streams in the respective shipments. Of the 301 drums in Disposals 195 and 196, 169 contained 741-series sludge. Of the 293 drums in disposals 205, 206, and 207, 137 contained 741-series sludge. Table 6 lists the contents of the five shipments.

The americium and neptunium focus area is being investigated to determine a fingerprint of this high-activity waste stream in the SDA environment. Both Am-241 and Np-237 showed potential risks greater than 1E-06 in the Interim Risk Assessment. Most of the Np-237 is produced through the decay of Am-241. The primary waste stream for Am-241 is RFO-DOW-3H, which contains more than 80% of the Am-241 buried in the SDA and is primarily uncemented sludge. Disposal of this waste stream occurred from 1954 to 1970.

Prior to installation of the Type A probes, there was some uncertainty whether this waste stream could be located. Results of the Type A logging data indicate that the waste was encountered and logged during the Type A activities. Preliminary results of the Type A nuclear logging data are given in letter

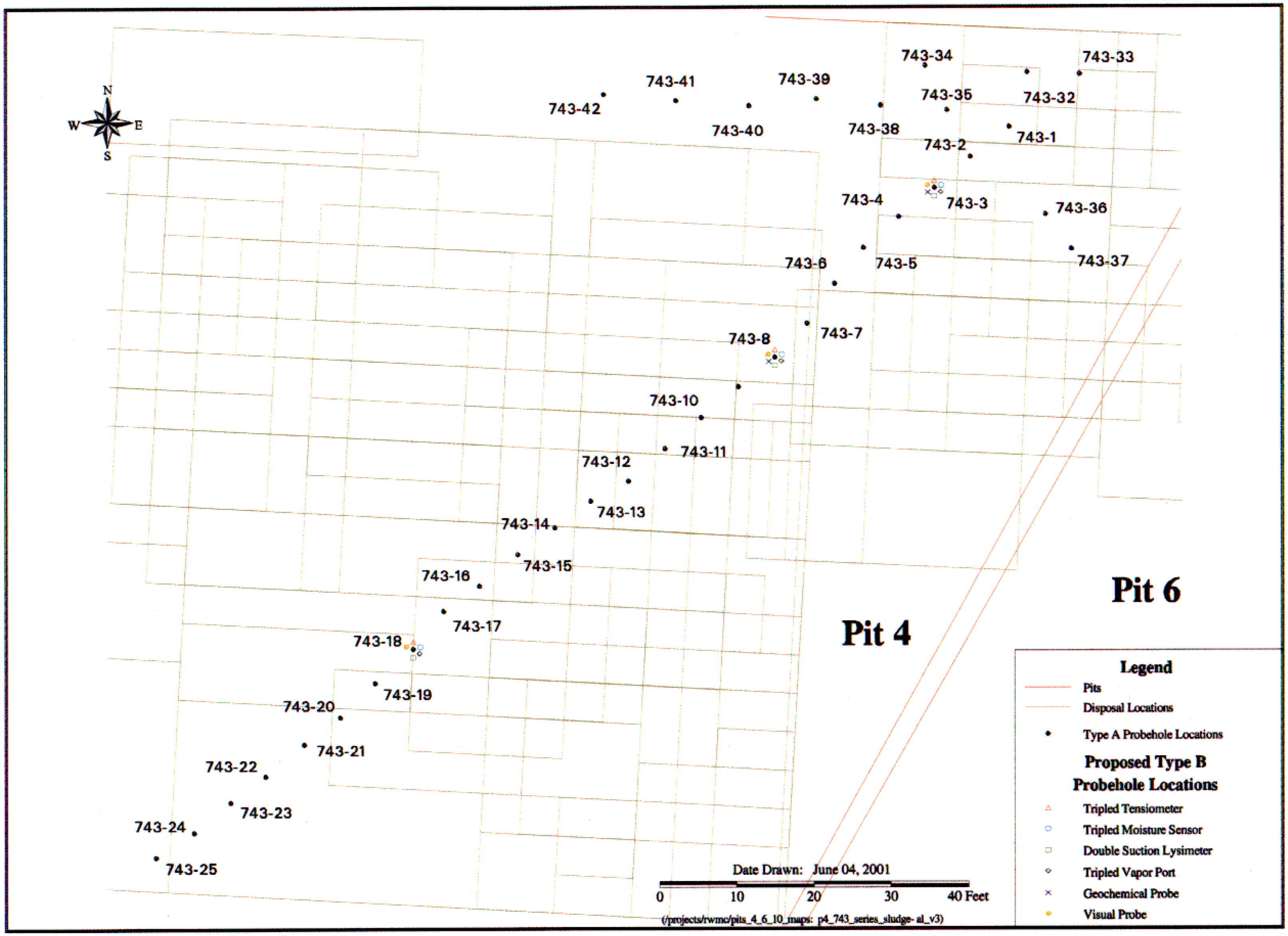

Figure 8. Proposed Type B probe clusters at the organic sludge focus area.

reports contained in Appendix D. Locations 741-2 and 741-8 had higher observed concentrations of Pu-239, Am-241, and neptunium than in other locations in this focus area. In addition, location DU-8 in the DU focus area contained an excellent source for monitoring neptunium waste.

At location 741-8, 8 ft (2.4 m) below ground surface (bgs), a high concentration of typical 741-bearing radionuclides (i.e., Plutonium [Pu], Am, Np) were found. A single narrow contamination zone with no other intermixed contamination was observed. The scientists evaluating the data set identified significant Np-237 enrichment relative to the amount expected from the decay of pure Am-241 (Mandler and Giles 2000). Significantly reduced contaminant concentrations were observed below the 8-ft (2.4-m) interval. This Type A probe will be the origin of a Type B cluster used to collect data on high-activity waste characteristics in the SDA. Directional logging data also provided a good basis for orienting the lysimeter planned to monitor the apparent source at this cluster.

Another candidate area was identified at location 741-2. At a depth of 11.5 ft (3.5 m) bgs, high concentrations of Pu, Am, and neptunium isotopes were also observed. Conditions in this probehole were similar to 741-8. Directional logging data also provided a good basis for orienting the lysimeter planned to monitor the apparent source at this cluster.

Table 6. Contents of shipments evaluated for the 741-series sludge focus area.

Pit 10 Disposals	Location	Rocky Flats Plant Generator	Description	INEEL Waste Stream Identfication	Drum Count	Drum Weight (lb)	Cont. Type	Disposal Date
195	60 to 70 ft north and 120 ft east of S/W monument	741	Type IV	RFO DOW 3H, 41H, 42H	103	30,508	30 gal	6/3/69
	Note: reference to S/W monument is presumed incorrect and should be S/W-2 (INEEL 2000)	771	21 Type V, 26 Type I	RFO DOW 9/10H, 4H, 41H	47	6,095	55 gal	6/3/69
		559	Type I	RFO DOW 4H, 41H	6	750	55 gal	6/3/69
		776	Type I	RFO DOW 4H, 41H	13	1,536	55 gal	6/3/69
196	50 to 80 ft north and 120 ft east of S/W monument	741	Type IV	RFO DOW 3H, 41H, 42H	66	33,395	55 gal	6/5/69
	Note: reference to S/W monument is presumed incorrect and should be S/W-2 (INEEL 2000)	771	16 Type V, 46 Type I	RFO DOW 9/10H, 4H, 41H	62	7,303	55 gal	6/5/69
		776	Type I	RFO DOW 4H, 41H	2	264	55 gal	6/5/69
		559	Type I	RFO DOW 4H, 41H	2	219	55 gal	6/5/69
205	70 to 80 ft south and 415 to 430 ft east of N/W monument	741	Type IV	RFO DOW 3H, 41H, 42H	52	15,255	30 gal	6/18/69
		776	Type I and V	RFO DOW 4H, 9/10H, 41H	2	263	30 gal	6/18/69
		771	Type I and V	RFO DOW 4H, 9/10H, 41H	50	3,948	30 gal	6/18/69
206	80 to 90 ft south and 415 to 430 ft east of N/W monument	741	Type IV	RFO DOW 3H, 41H, 42H	52	15,586	30 gal	6/18/69
		771	Type I and V	RFO DOW 4H, 9/10H, 41H	52	4,481	30 gal	6/18/69
207	60 to 70 ft south and 415 to 430 ft east of N/W monument	741	Type IV	RFO DOW 3H, 41H, 42H	33	16,414	55 gal	6/18/69
		771	Type I and V	RFO DOW 4H, 9/10H, 41H	52	4,541	30 gal	6/18/69

The final Type A probe, used to center Type B probes to study americium and neptunium waste, was actually identified in the DU focus area. Type A logging data summarized in Appendix D indicated that the highest concentration of Np-bearing waste was detected at DU-8 and, as such, DU-8 was determined to be an excellent candidate site to monitor waste of this type. The lysimeter planned to monitor this material will be placed at approximately 14.5 ft (4.4 m) bgs, the depth where the highest neptunium waste was encountered. The probes planned for DU-8 are shown in Figure 7, which represents the DU focus area.

Table 9 summarizes the Type B probes and recommended lysimeter placement for targeted lysimeters being installed at the selected cluster locations. Completion of other probes in these clusters will be consistent with the generic approach described in Section 2. Figures 7 and 9 indicate the approximate locations of the three currently funded probe clusters used to characterize americium and neptunium waste. The following set of Type B probes was planned to be installed as part of the americium and neptunium investigation, although some of these probes are presently funding limited:

- Three tensiometer and moisture sensor bundles
- Four lysimeter bundles
- One geochemical probe
- Three visual probes.

3.2.4 Pit 5 Investigation

The main purpose for investigations within Pit 5 is to attempt to identify the source of anthropogenic uranium detected in a lysimeter in Well TW-1, completed approximately 102 ft (31 m) bgs.[f] Uranium detected in this well was enriched in U-235 composition relative to natural or DU. It also contained U-236, a manmade radioisotope. Another purpose of the investigation is to identify VOC source material within the pit. Disposal records for organic sludge, as well as the limited calendar year (CY) 2000 soil-gas survey described in the Probehole Plan, will also be used to site probe-installation locations. Two areas will be investigated using Type B probes within Pit 5 for this purpose.

Final selection of the Type B locations will also be based on the results of initial Type A probe logging planned for installation, and logging to be completed by the summer of 2001. Five Pit 5 disposals (described below) were targeted for Type A probe installation and logging to identify additional sources of nondepleted uranium disposed in Pit 5. Table 7 provides information on these targeted disposals.

Bulk uranium was handled at the following primary facilities at Rocky Flats Environmental Technology Site:

- Building 444: Building 444 was a multipurpose manufacturing facility with an emphasis on manufacturing DU and beryllium components. Parts were cast, fabricated, assembled, and inspected in the facility.
- Building 881: Building 881 focused on enriched uranium manufacturing and recovery through the mid 1960s. Building 881 was also involved in numerous special projects, including work on U-233.

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f. Roback, C., D. W. Efurd, M. T. Murrell, and R. E. Steiner, July 20, 2000, "Assessment of U and Pu in the Saturated and Unsaturated Zones Beneath the Surface Disposal Area, INEEL (Draft)," Los Alamos National Laboratory, Los Alamos, New Mexico.

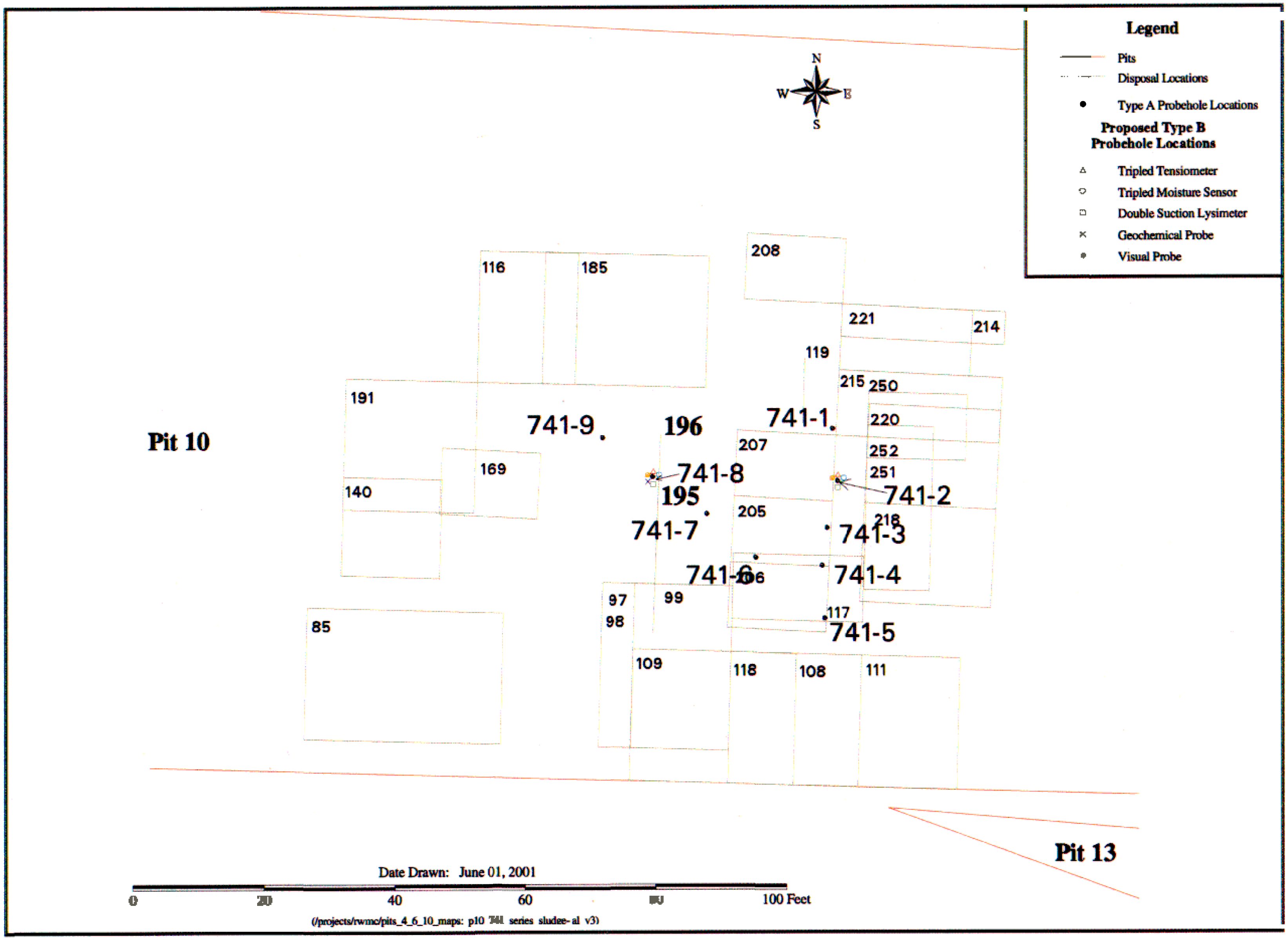

Figure 9. Proposed probe clusters at the americium and neptunium focus area.

Table 7. Pit 5 targeted waste shipment for installation of Type A probes.

Targeted Location	Rocky Flats Generator	Type	INEEL Waste Stream Identification	Location	Number of Containers	Weight of Containers (lb)	Total Volume (ft^3)	Document Identification Number	Disposal Date	Surface Radiation (mR/hour)
Pit 5-1	881	U-233	RFO-DOW-19H	100 ft west of S/E monument	10 (55-gal)	2,321	74	RFODOWSR105/22/65 80010	5/26/65	1
Pit 5-1	881	U-233	RFO-DOW-19H	100 ft west of S/E monument	29 (55-gal)	3,482	213	RFODOWSR105/22/65 81010	5/26/65	1
Pit 5-2	881	Type I and Type V	RFO-DOW-18H-V, 11H-V, 6H-III, 4H-I	190 ft north and 25 ft east of the SW monument	6 (55-gal)	790	44	RFODOWSR109/16/66 81020	9/23/66	1.5
Pit 5-3	881	Type I	RFO-DOW-4H	60 ft east and 125 ft north of the SW monument	42 (55-gal)	4,691	309	RFODOWSR104/29/66 80070	5/6/66	7
Pit 5-4	886	Type I and Type V	RFO-DOW-4H, 9/10H	50 ft east and 175 ft north of the S/W monument	14 (55-gal)	1,428	103	RFODOWSR108/12/66 81020	8/19/66	2

- Building 883: Building 883 was used to assist with fabrication of enriched and DU parts used in weapon production.
- Building 886: Building 886 was primarily used to conduct criticality tests on highly enriched uranyl nitrate.

The justification for selecting Pit 5 disposals for the initial Type A investigation is given below. Limited information exists that describes the contents of the disposals. In addition, disposal location information within the pit can only be considered approximate. Furthermore, waste of interest within a disposal was typically a minority of the total waste types within the disposal. Depleted uranium disposals have already been identified and logged as part of the initial Type A investigation, which was primarily focused in the western portion of Pit 10. Therefore, primary DU generators (i.e., Buildings 444 and 883) were not considered targets for this evaluation, although it is recognized that disposal originating from Building 883 could contain enriched uranium. Thirty Type A probes are planned to be installed and logged to support evaluation of an appropriate site for subsequent Type B cluster installation. The 30 Type A probes will be established in the following four general areas (see Figure 10).

3.2.4.1 Pit 5-1. An area identified as Pit 5-1 was targeted to place Type A probes because it contains what appears to be two collocated disposals of U-233 containing waste from Building 881. Thirty-nine of the 370 drums contained in these two disposals contained U-233 drums from Building 881. Another three drums from these two disposals were reported to contain U-233 from Building 771. Another important consideration in selecting this site for investigation was its disposal location along the southern perimeter of Pit 5. Disposal location information near the pit boundary is assumed to be more accurate than information near the center of a large pit like Pit 5.

3.2.4.2 Pit 5-2. An area identified as Pit 5-2 was targeted because it was the only Pit 5 location known to contain waste type 18H (i.e., enriched uranium), and drums within the disposal contained elevated surface radiation dose rates of 1.5 mR/hour. Six of the 150 drums within this disposal originated from Building 881 and may contain enriched uranium waste, including crucibles and high-efficiency particulate air (HEPA) filters. Five of the drums in this shipment also contained waste originating in Building 444, some of which contained DU. Disposals containing both enriched uranium and DU waste types may be a negative attribute because this could complicate logging interpretation if the drums were collocated. However, the fact that enriched uranium was identified in the disposal records outweighed this consideration.

3.2.4.3 Pit 5-3. An area identified as Pit 5-3 was targeted to place Type A probes because 42 of the 152 drums in the disposals originated from Building 881 and were described as combustibles in the form of rags and paper. In addition, three additional drums within the shipment contained U-233 waste. Drums within the disposal also contained some of the highest surface radiation dose rates (7 mR/hour).

3.2.4.4 Pit 5-4. An area identified as Pit 5-4 was targeted for placement of Type A probes because 14 of the 147 drums in this disposal originated from Building 886, a building established to perform criticality testing on highly enriched uranyl nitrate. All but 16 of the drums in this disposal originated from uranium processing facilities (i.e., Building 881, 883, or 886), making uranium detection likely. However, as stated before, Building 883 waste could contain DU, thereby complicating analysis. In an informal telecommunication with H. Salomon,[g] J. Anderson indicated that two enriched uranium-contaminated glove boxes and associated piping were disposed of many years ago (timeframe unknown).

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g. J. Anderson, radiological engineer and current Building 886 facility manager, telecommunication with H. Salomon, November 26, 2001.

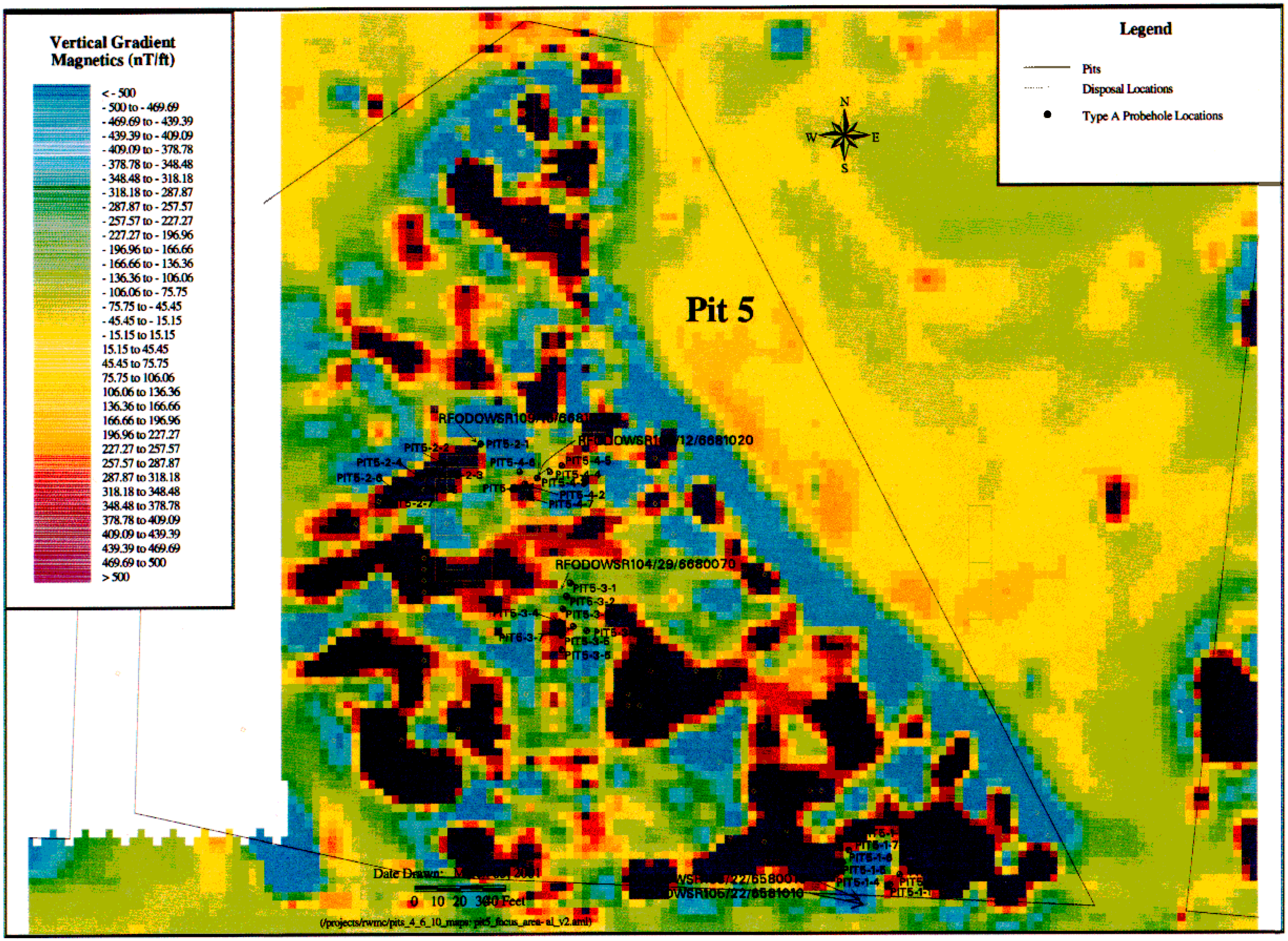

Figure 10. Proposed Type A probehole locations in Pit 5.

Information concerning this disposal indicates that these waste areas contain glove box decontamination, dismantlement, and decommissioning-type waste and combustibles, which would be expected from cleanups or decontamination operations. This material could be expected to contain higher concentrations of enriched uranium. Anderson also noted that numerous spills in Building 886 (e.g., highly enriched uranyl nitrate) were often mopped up. If disposed of, these mops (i.e., combustibles) would contain significant U-235 activity. Once the Type A investigation is completed at Pit 5, the following set of Type B instruments are expected to be located for installation:

- Two tensiometer and moisture sensor bundles
- Two lysimeter bundles
- Two vapor port bundles
- Two geochemical probes
- One visual probe.

3.2.5 Pit 6 Investigation

Three bundles of vapor ports and one visual probe will be installed in Pit 6 (see Figure 11). In accordance with the Probehole Plan, a combination of CY 2000 shallow soil gas surveys and 743-series sludge disposal information was used to site the locations. The following three disposals were targeted for investigation:

- Disposal RFODOWSR109/22/67800 contained 129 drums, of which 35 were identified to contain 743-series sludge. This disposal was located in the northwestern corner of Pit 6 and had the highest concentration of CCl_4 identified in Pit 6 during the CY 2000 shallow soil-gas survey. A vapor port bundle and visual probe will be installed where this disposal was described to have been disposed. This location will be identified as Pit 6-1.

- Disposal RFODOWSR105/03/68800 contained 76 drums, of which 59 were identified to contain 743-series sludge. This disposal was located in the north-central portion of Pit 6 and also contained elevated concentrations of CCl_4 identified during the CY 2000 shallow soil-gas survey. A vapor port bundle will be installed here and the location will be identified as Pit 6-2.

- Disposal RFODOWSR110/19/67800 contained 152 drums, of which 35 were identified to contain 743-series sludge. This disposal was located in the southeastern portion of Pit 6 and also contained elevated concentrations of CCl_4 identified during the CY 2000 shallow soil-gas survey. A vapor port bundle will be installed here and the location will be identified as Pit 6-3.

Figure 11 contains the locations of the three targeted waste zones and proposed probehole locations superimposed over the results of the CY 2000 shallow soil-gas survey.

3.2.6 Moisture Monitoring Network

In addition to the investigations in Pits 4 and 10 to evaluate the various focus areas, tensiometer and soil moisture sensor probe bundles will be placed in additional locations in and adjacent to the pits to evaluate infiltration characteristics caused by standing water and snow melt in ditches. Three north-to-south trending transects, each made up of three tensiometers and moisture-sensor bundles, will be

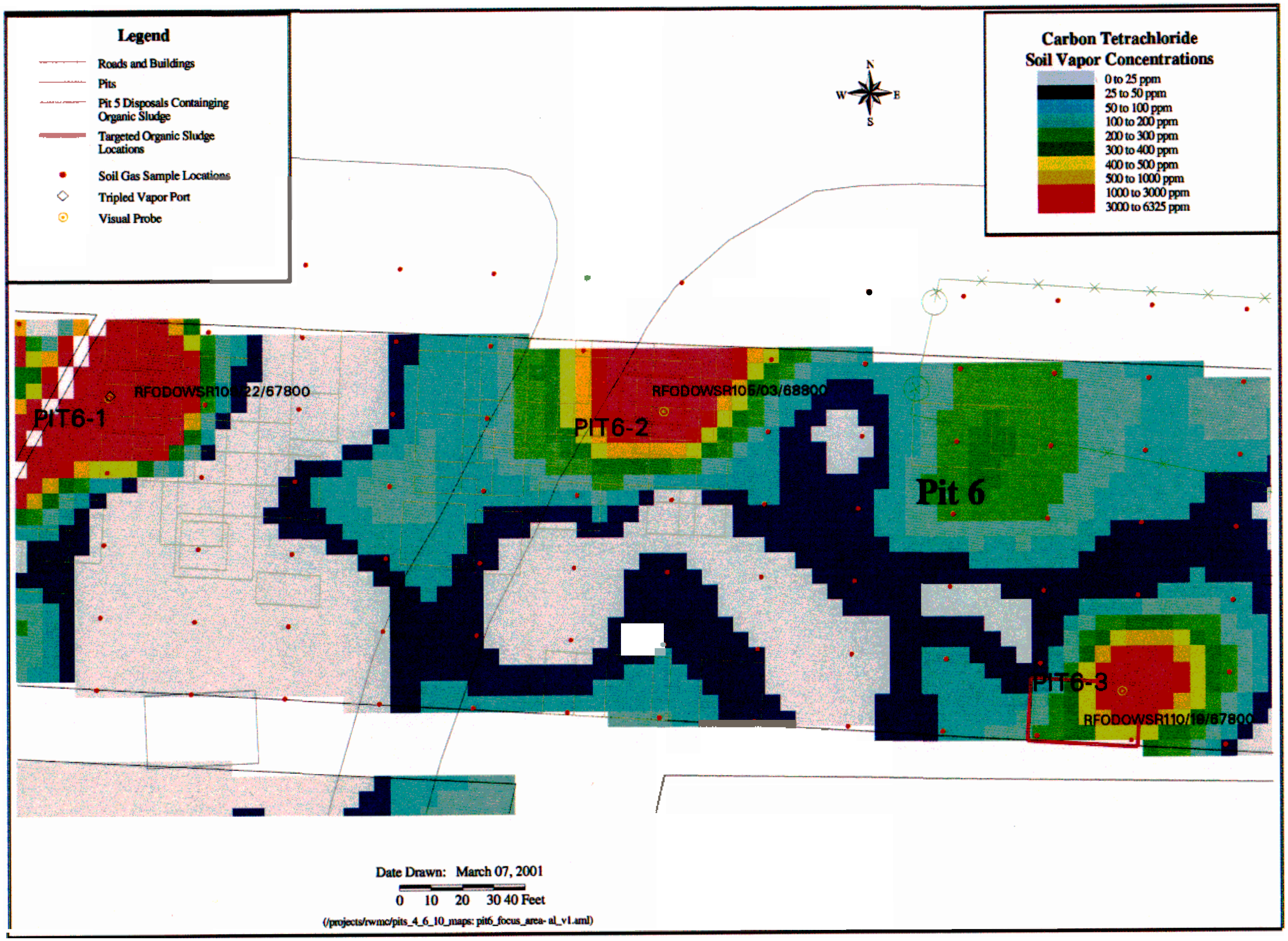

Figure 11. Proposed Type B probehole locations in Pit 6.

established in and adjacent to Pit 4 (see Figure 3). These bundles should be arranged such that the nested probes in each bundle form a line that is essentially parallel to the ditch on the north side of Pit 4. Nested probes are considered to represent the same horizontal position, yet completed (i.e., installed) to represent different vertical positions. The MM1 tensiometer transect is located to monitor the effect of water that flows through a culvert under the east-west road. The MM2 transect is centrally located along the northern edge of Pit 4 and is located in a slight topographic depression (especially MM2-3). The MM3 transect is located just east of the I-3 monitoring well pair which showed wet conditions above the BC interbed at a depth of ~90 ft (27 m).

Another five tensiometer and moisture-sensor bundles (i.e., the MM4 network) will be installed to form an array around the DU focus area to evaluate infiltration characteristics in that area. Some of these probes will be located in an area believed to contain a topographic depression on the underlying basalt surface. Several of the probes in this location are located along the drainage ditch that borders the southwest corner of Pit 10. Probes MM4-2 and MM4-3 have been located in areas that have high surface elevations with good surface water runoff. These locations are specifically biased toward areas of suspected low infiltration to monitor moisture behavior in areas with less favorable infiltration potential.

3.2.7 Activated Metal (Stainless Steel) Investigation at Soil Vault Row 12

Carbon-14 is an activation product and hence a byproduct of reactor operations. There is uncertainty about the amount of C-14 disposed of in the SDA and the release rate of the disposed C-14. The release rate for C-14 is believed to be controlled by the type of base metal in which it was formed (e.g., activated stainless steel or activated beryllium). There is an ongoing effort to refine the inventory of C-14 in the SDA. Using the current assumptions on release rate, preliminary evaluations of the potential risks from the Interim Risk Assessment indicate that C-14 may still be above acceptable risk levels.

Most of the C-14 inventory in the SDA is from disposal of activated metal. Some of this is in the form of reactor core components, including beryllium reflector blocks and end pieces from naval reactor cores. The remaining activity is mostly in ion exchange resins. Because of how the C-14 is generated, it is contained in high-activity waste. As such, it is disposed of in locations separate from the other contaminants discussed. Typical disposals were in the SVRs, or possibly trenches, in the earlier years of operation. Carbon-14 can be transported in both the vapor and dissolved phases. It is anticipated that Type B probes near the appropriate soil vaults can yield information regarding the release and potential transport of C-14 in the subsurface. Moisture monitoring will also be conducted near the vault because the moisture state of the surrounding soil affects the sampling and evaluation of soil gas data.

Two activated metal disposal sites will be evaluated during this investigation. This section describes the evaluation for activated stainless steel while the following section describes additional monitoring at a site in which activated beryllium has been disposed of.

Objectives of choosing an optimal soil vault location to monitor activated stainless include the following:

- Locating highly activated stainless steel.
- The location can contain no activated beryllium in or near the soil vault of interest. This is done to mitigate overestimation of C-14 release, because beryllium is known to release this isotope at significantly greater rates than stainless steel. Some of the TRA Advanced Test Reactor core material contains activated beryllium (Logan 1999), which is the focus of other probes described in the following section.
- Sites containing only activated zircaloy should also be avoided. Some Naval Reactors Facility disposals contain zircaloy. If a site containing no activated stainless steel (e.g., just containing

activated zircaloy) was mistakenly sampled, erroneously low concentrations of activation products would be expected.

- Monitored material must have direct contact with soil (i.e., activated metal must be open to the environment). Typical scrap casks used to dispose of some of the Naval Reactors Facility activated end pieces from naval cores are believed to be completely sealed. In this configuration, activated metal would not leach until the cask itself deteriorated.

- Older material improves the chance of collecting contaminants of interest in leachate, providing the disposal records are adequate.

Soil Vault Row 12 contains numerous disposals of what is believed to be activated stainless steel. Information gathered through conversations with past and present INEEL personnel indicate that these disposals are probably stainless steel end pieces from spent Experimental Breeder Reactor II fuel elements and are highly irradiated. Spent fuel elements from Experimental Breeder Reactor II were sent to the Idaho Nuclear Technology and Engineering Center (INTEC), previously called the Idaho Chemical Processing Plant (ICPP), for processing after use. The stainless steel end pieces were physically separated from the fuel in underwater basins at CPP-603 before disposal at RWMC. This material is also expected to contain no beryllium. Discussion with personnel familiar with the subject disposals indicate that the material was disposed of in scrap cask inserts that were both open at the top and perforated on the bottom. The perforations were designed to allow draining once removed from the storage basin at CPP-603.

In a conversation with RWMC operations personnel,[h] it was indicated that because of shallow soil conditions at SVR-12, these disposals were not made in the typical fashion of placing waste in an auger hole, as routinely done at RWMC soil vaults. Rather, a shallow hole was made with conventional excavation equipment and the scrap cask inserts were placed in the excavation, using a free air transfer technique. This was done remotely because the disposed waste had a very high radiation field associated with it. As a result, exact positioning of the disposed waste was not possible.

It was also noted the basalt surface in that area was no deeper than 8 to 12 ft (2 to 4 m) bgs at the time of disposal. However, because of subsequent flooding, RWMC operations placed approximately 10 ft (3 m) of fill in an area close to where these shipments were disposed. Ten disposals, originating from CPP-603, were placed in SVR-12 and are all thought to have been activated stainless steel. Table 8 provides information from the WasteOScope database, which is an INEEL ArcInfo application for these disposals. These CPP-603 activated stainless steel disposals were all made between May and July 1982. Information in the WasteOScope database, other than disposal position and disposal date, is consistent between all 10 disposals.

Geophysical surveys, along with available disposal information, were evaluated to determine optimal placement of Type B probes to monitor this activated stainless steel. This evaluation, including planned placement of probes, is detailed in Appendix E.

The investigation at SVR-12 will include installation of the following instruments:

- One tensiometer and moisture sensor bundle

- One lysimeter bundle

h. James B. Bishoff, RWMC Operations, telecommunication with Hopi Salomon, May 17, 2001.

Table 8. Information from the WasteOScope database about possible activated stainless steel disposal at Soil Vault Row 12.

Disposal Location	Generating Area	Shipment Number	Disposal Date	Container Type	Number of Containers	Gross Volume (m^3)	Gross Weight (g)	Activity (Ci)	Nuclide Identification	Curies
SVR120+10	CPP-603	NCMP ICP82-254	5-May-82	I	1	0.8213	544,300	14,000	Co-58	7,840
									Co-60	140
									Cr-51	420
									Fe-59	140
									Mn-54	5,460
SVR120+10	CPP-603	NCMP ICP82-293	20-May-82	I	1	0.8213	544,300	14,000	Co-58	7,840
									Co-60	140
									Cr-51	420
									Fe-59	140
									Mn-54	5,460
SVR120+20	CPP-603	NCMP ICP82-327	2-Jun-82	I	1	0.8213	544,300	14,000	Co-58	7,840
									Co-60	140
									Cr-51	420
									Fe-59	140
									Mn-54	5,460
SVR120+55	CPP-603	NCMP ICP82-357	21-Jun-82	I	1	0.8213	544,300	14,000	Co-58	7,840
									Co-60	140
									Cr-51	420
									Fe-59	140
									Mn-54	5,460
SVR120+55	CPP-603	NCMP ICP82-372	30-Jun-82	I	1	0.8213	544,300	14,000	Co-58	7,840
									Co-60	140
									Cr-51	420
									Fe-59	140
									Mn-54	5,460
SVR120+65	CPP-603	NCMP ICP82-388	30-Jun-82	I	1	0.8213	544,300	14,000	Co-58	7,840
									Co-60	140
									Cr-51	420
									Fe-59	140
									Mn-54	5,460

Table 8. (continued).

Disposal Location	Generating Area	Shipment Number	Disposal Date	Container Type	Number of Containers	Gross Volume (m^3)	Gross Weight (g)	Activity (Ci)	Nuclide Identification	Curies
SVR120+75	CPP-603	NCMP ICP82-406	8-Jul-82	I	1	0.8212	544,300	14,000	Co-58	7,840
									Co-60	140
									Cr-51	420
									Fe-59	140
									Mn-54	5,460
SVR120+85	CPP-603	NCMP ICP82-420	13-Jul-82	I	1	0.8212	544,300	14,000	Co-58	7,840
									Fe-59	140
									Mn-54	420
									Co-58	140
									Co-60	5,460
SVR121+22	CPP-603	NCMP ICP82-423	21-Jul-82	I	1	0.8212	544,300	1,400	Co-58	784
									Co-60	14
									Cr-51	42
									Fe-59	14
									Mn-54	546
SVR121+32	CPP-603	NCMP ICP82-448	28-Jul-82	I	1	0.8212	544,300	1,400	Co-58	784
									Co-60	14
									Cr-51	42
									Fe-59	14
									Mn-54	546

- Up to three vapor port bundles
- One geochemical probe.

It is critical that the lysimeter bundle installed at this site be located as close as possible to the waste disposal. Nonvolatile radionuclides released from the activated stainless steel are not expected to be released at significant rates or at high concentrations. Therefore, locating this lysimeter bundle within 1 to 2 ft (0.3 to 0.6 m) from the waste disposal is critical for meaningful samples to be collected here. For a potential cost-saving measure, installation of only one bundle of vapor ports (e.g., the bundle to be installed closest to the source) may be considered until analytical data demonstrate that the identified source is releasing contaminants.

3.2.8 Activated Metal (Beryllium) Investigation at Soil Vault Row 20

Six neutron-activated beryllium reflector blocks from the INEEL Advanced Test Reactor were buried in SVR-20 in 1993. The blocks contained 293,000 Ci of tritiated hydrogen gas and 32 Ci of C-14 (LMITCO 1999). These radionuclides form compounds that are mobile in both the liquid and gas phases of the vadose zone. Conservative assumptions used in the Interim Risk Assessment identified C-14 as the primary contributor to potential risk from sources of activated metal waste buried in the SDA. In addition to the results of the Interim Risk Assessment, C-14 was identified as a dose contributor in the RWMC performance (Case et al. 2000).

Samples collected from this site will be analyzed for both C-14 and H-3 to evaluate the validity of the assumptions used in the Interim Risk Assessment. Tritium, though not a contaminant of potential concern, is being analyzed because it is easier to measure, and it reflects the corrosion of the blocks and release of C-14 and other radionuclides. In addition, tritium is not expected to attenuate during transport, while C-14 could react with the surrounding media. Therefore, though C-14 is more important from a risk perspective, monitoring for tritium will provide valuable data because it is expected to offer more direct information regarding release characteristics from the source.

A minimal monitoring network of one neutron access tube, three nested gas ports, two nested lysimeters, and two thermistors already exist around SVR-20, 0 + 315 ft (0 + 96 m). The monitoring conducted under this section will be used to augment the monitoring that began in 1994. The main addition is the installation of a radial array of bundled vapor ports to enhance monitoring tritium and C-14. Moisture monitoring will also be conducted near the vault because the moisture state of the surrounding soil affects the sampling and evaluation of soil gas data. The investigation at SVR-20 will include installation and monitoring of the following instruments:

- One tensiometer and moisture sensor bundle
- Five vapor port bundles
- One geochemical probe.

Figure 12 depicts the approximate locations proposed for installation of the nested probe bundles. Vapor port bundles should be completed at approximately 7, 13, and 19 ft (2, 4, and 6 m) below land surface. Vapor ports should be oriented so that the individual probe in each bundle of nested probes is placed at approximately the same radial distance from the original SVR auger hole being monitored. In addition, the three sensors in the soil moisture probe should be assembled so that the vertical placement of each sensor corresponds with the same (as close as possible) vertical horizon used for completion of the vapor ports, so that temperature measurements made by the soil moisture probe sensors can be used to assume temperatures of the soil gas being collected in each "nested" vapor port.

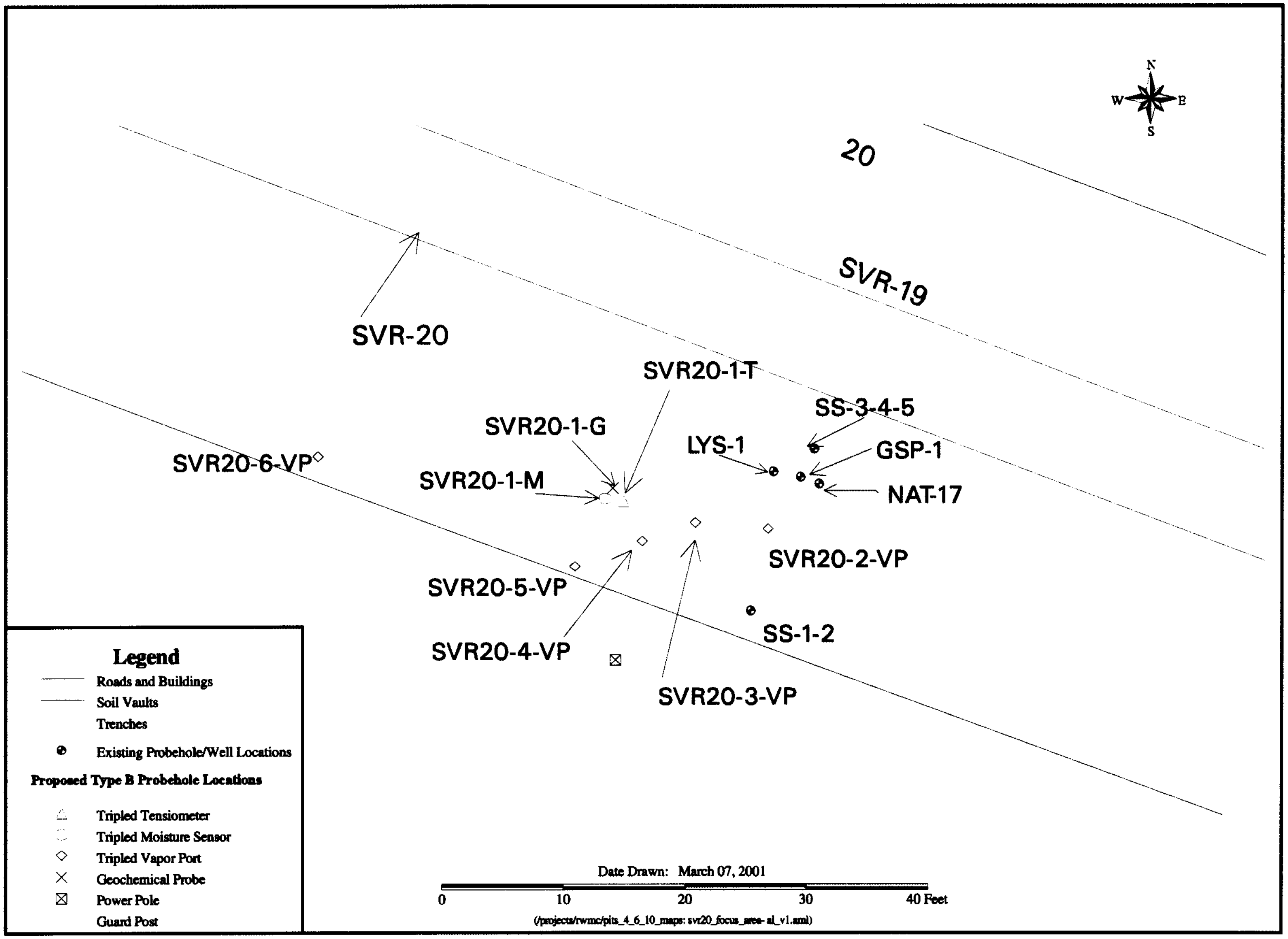

Figure 12. Proposed Type B probehole locations surrounding Soil Vault Row 20.